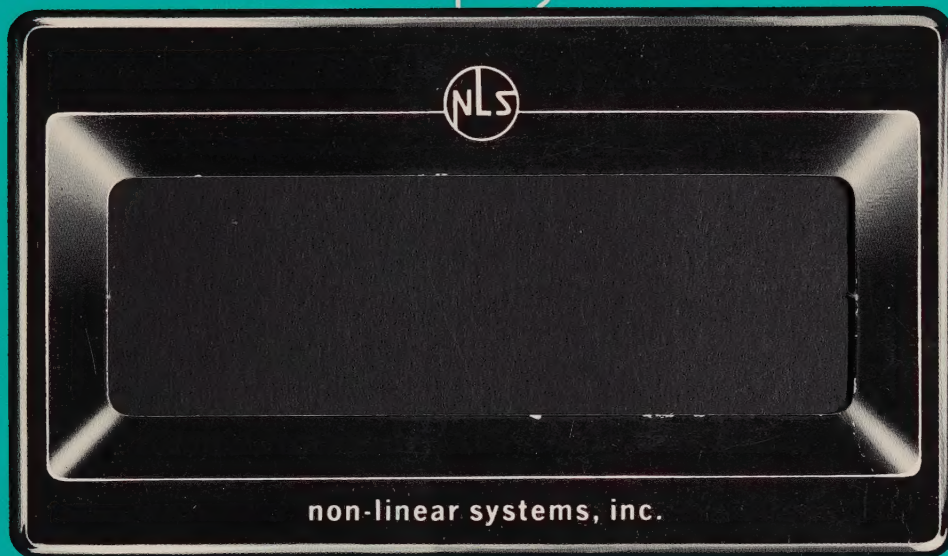


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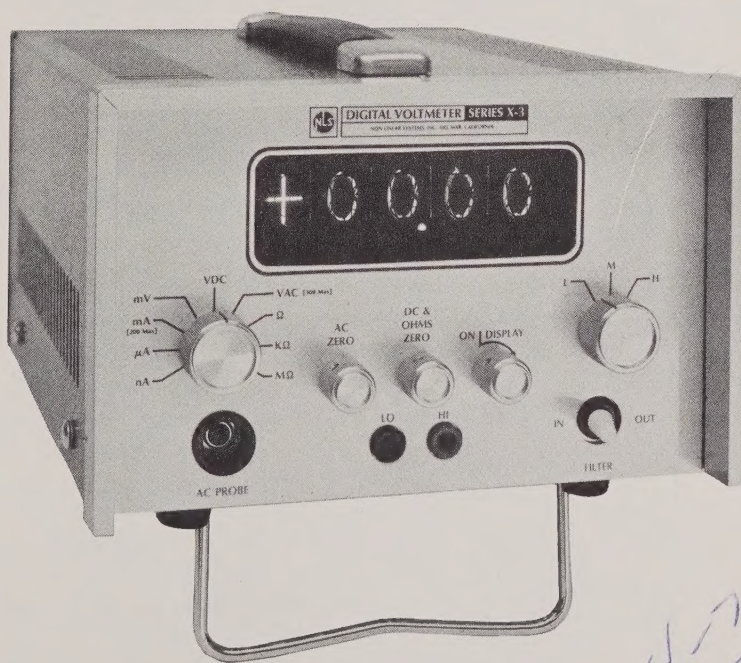
non | linear
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DEL MAR, CALIFORNIA

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INSTRUCTION MANUAL
SERIES X-3
(MODEL A)
DIGITAL VOLTMETER



This Document applies to Series X-3 DVM's bearing
Part Number 38-4 (S/N X-3.2000 & Subsequent).



Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR (SAN DIEGO), CALIFORNIA

Printed in the United States of America

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CHAPTER I

INTRODUCTION AND SPECIFICATIONS

The Series X-3 Multipurpose Digital Voltmeter is a light weight, portable, three-digit instrument with automatic polarity and with provisions for 1999 counts to full scale in most ranges and functions (See specifications for exceptions).

The measuring capabilities of the Series X-3 include eight current ranges, (nine with external shunt), nine ohms ranges, three millivolt (DC) ranges, three VDC ranges and three VAC ranges. An additional DC range (10 KV) may be obtained

by use of a high voltage probe.

Another unique feature of the X-3 is an analog output proportional to the signal being measured. Connectors for this purpose are located on the rear of the instrument.

The Series X-3's circuitry is all solid state and its speed and accuracies are considerably higher than any other instrument in its class.

SPECIFICATIONS

DC VOLTAGE

RANGE	OVER-RANGE	RESOLUTION	ACCURACY*
10 mV	19.99 mV	10 μ V	0.2% Rdg. + 0.5% F. S.
100 mV	199.9 mV	100 μ V)	
1000 mV	1999. mV	1 mV)	
10 V	19.99 V	10 mV)	
100 V	199.9 V	100 mV)	0.1% Rdg. + 0.1% F. S.
1000 V	999.9 V (Maximum)	1 V	
10000 V (With Probe)	19.99 KV	10 V	3% Rdg. + 0.1% F. S.
100,000V (With Probe)	30.0 KV (Maximum)	100 V	3% Rdg. + 1.0% F. S.

DC CURRENT

10 nA	19.99 nA	10 pA	20% Rdg. + 0.5% F. S.
100 nA	199.9 nA	100 pA	5% Rdg. + 0.5% F. S.
1000 nA	1999. nA	1 nA	0.5% Rdg. + 0.5% F. S.
10 μ A	19.99 μ A	10 nA	0.2% Rdg. + 0.1% F. S.
100 μ A	199.9 μ A	100 nA)	0.1% Rdg. + 0.1% F. S.
1000 μ A	1999. μ A	1 μ A)	
10 mA	19.99 mA	10 μ A)	
100 mA	199.9 mA (Maximum)	100 μ A)	

*ASA Reference Conditions Only

SPECIFICATIONS (Con't)

OHMS

RANGE	OVER-RANGE		RESOLUTION	ACCURACY
10 Ω	19.99 Ω	@10 mA	10 m Ω	0.1% Rdg. + 0.2% F.S.
100 Ω	199.9 Ω	@1 mA	100 m Ω)	
1000 Ω	1999 Ω	@100 μ A	1 Ω)	0.1% Rdg. + 0.1% F.S.
10 K Ω	19.99 K Ω	@10 μ A	10 Ω)	
100 K Ω	199.9 K Ω	@1 μ A	100 Ω)	
1000 K Ω	1999 K Ω	@100 nA	1 K Ω	0.5% Rdg. + 0.1% F.S.
10 Meg Ω	19.99 Meg Ω	@100 nA	10 K Ω	1% Rdg. + 0.2% F.S.
100 Meg Ω	199.9 Meg Ω	@10 nA	100 K Ω	20% Rdg. + 0.2% F.S.
1000 Meg Ω	1999 Meg Ω	@1 nA	1 Meg Ω	Usable for relative measurements

AC VOLTAGE

10 V	19.99 V	10 mV	3% F.S. (0.5 V & Up)**
100 V	199.9 V	100 mV	3% F.S. **
1000 V (300 V Maximum)		1 V	3% F.S. **

Frequency Response: (400 Hz Reference)

$\pm 10\%$ - 20 Hz to 100 Hz

$\pm 2\%$ - 100 Hz to 100 MHz

$\pm 10\%$ - 100 Hz to 700 MHz

POWER: 105-125 Volts, 20 Watts.

DIMENSIONS: 6" High, 8-9/16" Wide, 11-29/32" Deep.

WEIGHT: Approximately 13 lbs.

* ASA Reference Conditions Only

** @400 Hz

CHAPTER II

INSTALLATION AND OPERATION

UNPACKING

The instrument is shipped in a heavy cardboard container. Cut the tape on the top of the container and open. If damage is observed, promptly notify the carrier. Immediately check the packing slip for possibility of shortages.

CAUTION

Do not operate the instrument before ensuring that each plug-in board is firmly in place. Failure to take this precaution may cause damage to components on the board assemblies.

POWER SOURCE

The instrument is usually supplied for operation from 105-125 volt, 50-400 Hz, single phase power sources. However, the instrument will operate from 210-250 volt, 50-400 Hz, single phase sources if the two primaries of the power transformer are wired in series instead of in parallel (See schematic diagram 38-110). The serial number tag at the rear of the instrument indicates the correct power source if other than 105-125 volts or 50-400 Hz.

FUSING

The instrument is protected by a 3AG 3/8 ampere fuse (F1) which is located on the rear panel. When a 210-250 volt power source is to be used (and the power transformer primary rewired as indicated above),

it is recommended that a 3/16 ampere fuse be used to provide maximum protection. Two additional fuses (F1 and F3) are located on the Attenuator Assembly (38-98) and the D/A Converter and Reference Assembly (38-107) respectively. F3 on assembly 38-107 is provided to guard the ohms input circuit against any inadvertant application of voltage or current into the ohms input connector. F1 on assembly 38-98 is provided to guard against any inadvertant application of current greater than the rating of the instrument.

POWER GROUNDING

The third pin of the power plug grounds the outer chassis of the instrument (Figure 2-1). Despite the presence of the third grounding pin, there is no real assurance that the instrument will be correctly connected since

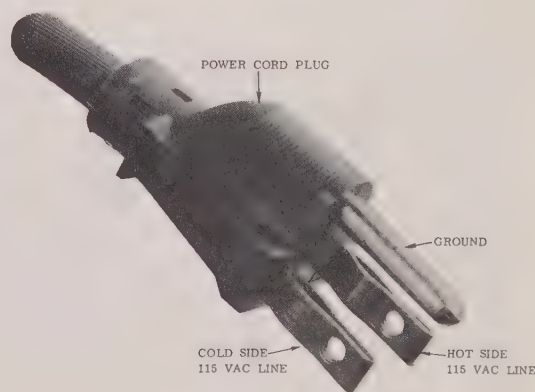


Figure 2-1. Power Plug Pin Coding

the power outlets in many installations are erroneously wired. Be certain that the power source is in agreement with the power and grounding requirements of the instrument.

CONNECTORS (Figures 2-2 & 2-3)

Three input connectors are located on the front panel of the instrument; they are color-coded and labeled as to function:

AC PROBE	Phone Jack (no color)
SIGNAL HI	Red
SIGNAL LO	Black

Five connectors are located on the rear panel. Two provide the analog output of the instrument (1mA maximum). The red connector is signal high; the black connector is signal low. Three connectors are labeled ACCESSORY POWER SUPPLY and provide

approximately 40 VAC at 200 mA.

CABLES

Three cables are provided with each instrument; the part number, color and function of each are as follows:

15004-608-3	Black	LO
15004-609	Red	HI
38-50	Black with Silver Probe	AC Probe

CONTROLS (Figure 2-2)

FUNCTION SWITCH

The function switch is a nine-position switch, located on the front panel of the instrument. The position for each measurement function is appropriately labeled (See Table I).

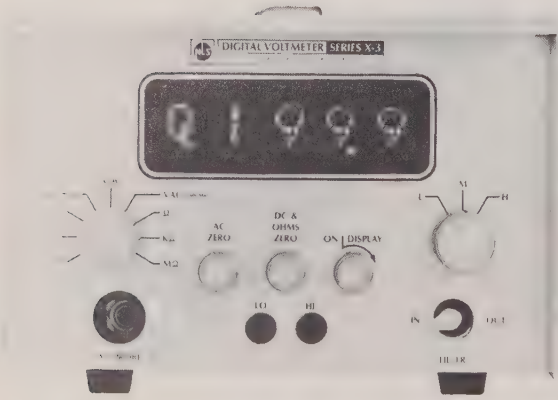


Figure 2-2. Front View

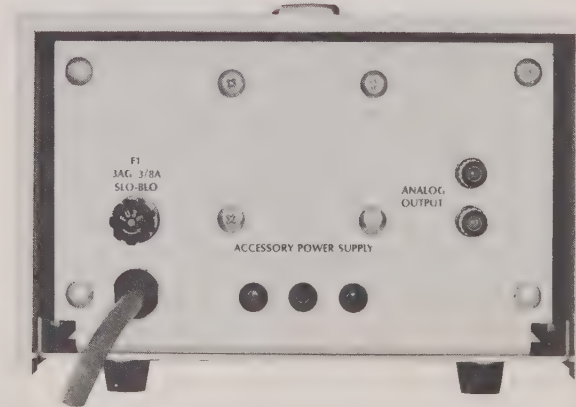


Figure 2-3. Rear View

Table I. Measurement Capabilities

FUNCTION SWITCH POSITION	RANGE SWITCH POSITION		
	L	M	H
nA	19.99 nA RANGE	199.9 nA RANGE	1999. nA RANGE
μ A	19.99 μ A RANGE	199.9 μ A RANGE	1999. μ A RANGE
mA	19.99 mA RANGE	100 mA RANGE (200 mA Max.)	2 AMPS Max. with External Shunt
MV	19.99 mVDC RANGE	199.9 mVDC RANGE	1999. mVDC RANGE
VDC	19.99 VDC RANGE	199.9 VDC RANGE	1000 VDC RANGE 1000 VDC MAX.
VDC	(30KV WITH PROBE)		
VAC	19.99 VAC RANGE (0.5V MIN)	199.9 VAC RANGE	1000 VAC RANGE 300 VAC MAX.
Ω	10.00 Ω RANGE	100.0 Ω RANGE	1999. Ω RANGE
K Ω	19.99 K Ω RANGE	199.9 K Ω RANGE	1999. K Ω RANGE
MEG Ω	19.99 MEG Ω RANGE	199.9 MEG Ω RANGE	1000 MEG Ω RANGE

NOTE: WHEN INSTRUMENT INDICATES 1999, RANGE/FUNCTION SWITCHES SHOULD BE ROTATED AS INDICATED BY ARROWS UNTIL A READING IS OBTAINED BETWEEN 0199 AND 1998. THIS WILL BE THE PROPER RANGE AND THE MOST ACCURATE READING OF WHICH THE INSTRUMENT IS CAPABLE WILL BE DISPLAYED.

RANGE SWITCH

The range switch is a three position switch, located on the front panel of the instrument. The positions for each range measurement are labeled L, M, and H (See Table I).

ON DISPLAY

The ON DISPLAY control, located on the front panel of the instrument, serves as a power switch and as a control to permit noisy input signals to be measured (turn clockwise). Maximum reading speed is obtained with this control turned counter-clockwise (up to the position that would turn the power off). Compensate for noisy signals by rotating this control clockwise as required.

AC ZERO

The AC ZERO control, located on the front panel of the instrument, is provided to zero the readout prior to taking VAC readings.

DC & OHMS ZERO

The DC & OHMS ZERO control, located on the front panel of the instrument, is provided to zero the readout prior to taking current, MVDC, VDC or ohms readings.

FILTER SWITCH

The FILTER SWITCH is a two position toggle switch and is located on the front panel of the instrument. It is labeled IN and OUT and is provided to attenuate noisy input signals. In the higher resistance ranges, the filter may be switched out to obtain faster readings.

DIGITAL READOUT

The instrument is supplied with five readout

tubes; polarity (+ or -) and overload ($\mathcal{Q}$) display; over-range (O) or (1) display; and three 0 thru 9 digital and decimal displays (left to right respectively). The $\mathcal{Q}$ display will illuminate when the input reaches full scale of the range in use.

OPERATION

1. Plug power cord into 115VAC, 50-400 Hz, single phase power source.
2. Turn ON DISPLAY control clockwise until an audible click is heard. Allow 30 minutes for instrument warm-up.
3. Place function switch in the position (as labeled) to obtain desired function to be measured (See Table I).
4. Place range switch in position to obtain desired range to be measured (Table I).

NOTE

To obtain measurements within instrument's specified accuracies, it is essential that the readout of the instrument be brought to all zeros prior to operation and prior to measurement after EACH range OR function change.

ZEROING THE READOUT

MVDC or VDC Zero

1. Place function switch in mV or VDC position.
2. Plug red and black input cables into their matching-color connectors or use a shielded input cable with standard 3/4-inch connector.
3. Connect leads of cables together and adjust DC & OHMS ZERO control until readout displays all zeros.

Current Zero

1. Place function switch in nA, μ A, or mA position.
2. Plug red and black input cables into their matching-color connectors or use a shielded input cable with standard 3/4-inch connector.
3. With leads of cables open, adjust DC & OHMS ZERO control until readout displays all zeros. Because of noise pick-up, a more accurate zero may be obtained in the nA mode if the red lead is removed from the instrument.

Ohms Zero

1. Place function switch in Ω , $K\Omega$, or $MEG\Omega$ position.
2. Plug red and black input cables into their matching-color connectors.
3. Connect leads of cables together and adjust DC & OHMS ZERO control until readout displays all zeros.

AC Zero

1. Plug VAC cable into AC PROBE con-

nector. Allow 5 minutes for warm-up.

2. Zero the instrument in VDC mode as set forth above.
3. Place function switch in VAC position.
4. Connect leads of cable together and adjust AC ZERO control until readout displays all zeros.

CABLE CONNECTIONS

For signal measurement, connect instrument cables to signal source as shown in applicable calibration instructions (Figures 4-3 thru 4-6).

NOTE

Since the circuitry in the Series X-3 Digital Voltmeter is not connected to power ground, differential measurements above ground may be made. However, the signal to be measured, should first be analyzed to determine which terminal has the lowest impedance to ground so that the black input lead (LO) of the X-3 may be connected to it.

CHAPTER III

THEORY OF OPERATION

INTRODUCTION

The Series X-3 consists of two basic sections. A Signal Conditioning Section conditions resistance, current and voltage inputs into a normalized DC analog signal. The Digitizing Section accepts a normalized analog signal from the Signal Conditioning Section and converts it into a visual digital display.

To assure ease of understanding, the Theory of Operation has been divided into the following two major paragraphs:

1. Signal Conditioning Section
2. Digitizing Section

Subdivisions within each of these major

paragraphs describe the various circuits making up each section. An overall schematic diagram of the instrument is located at the end of this chapter.

SIGNAL CONDITIONING SECTION

The Attenuator Board (p/n 39-98) converts and conditions resistance, current and voltage input signals into a linearized voltage. The linearized voltage is equal to three millivolts at the output of the buffer amplifier A1 (p/n 38-64) for each digit to be displayed in the readout. Scaling and conditioning of the many functions of the X-3 are discussed in the following paragraphs; simplified schematic diagrams are presented to augment the discussion.

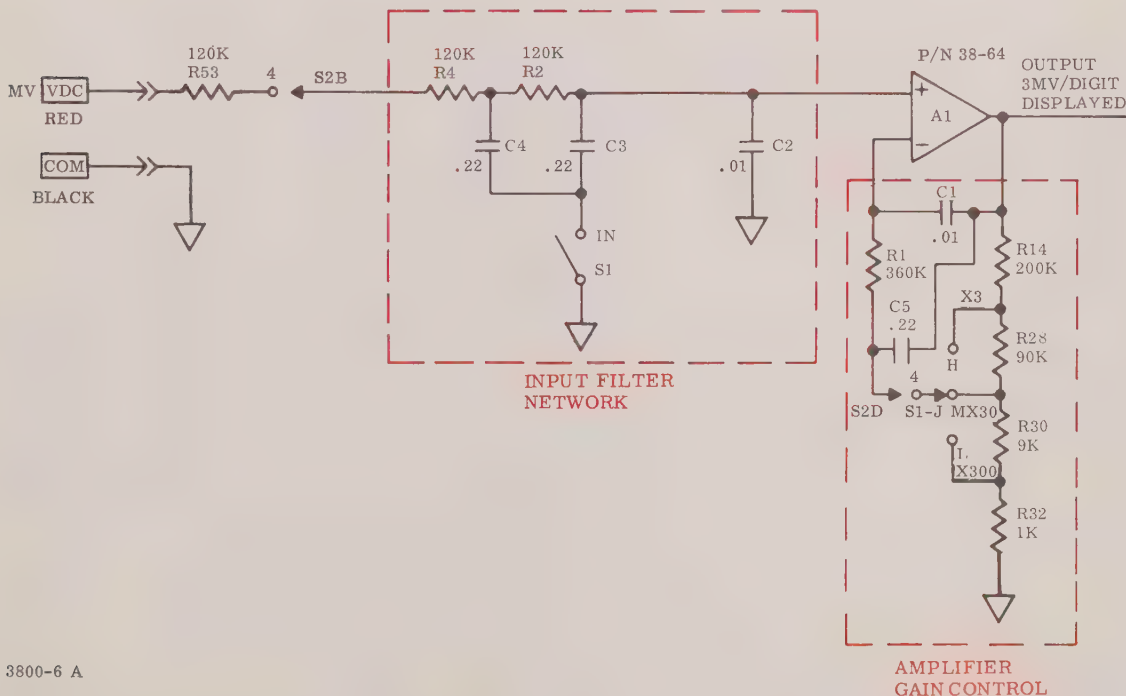


Figure 3-1. Signal Conditioning for Millivolts DC Measurement

SIGNAL CONDITIONING FOR MILLIVOLT DC MEASUREMENT (Figure 3-1)

In the millivolt DC mode, the voltage being measured is connected directly to the input buffer amplifier A1 (p/n 38-64). The input amplifier A1 is connected potentiometrically to provide high input impedance at gains of 300, 30 and 3 on the Low, Medium and High ranges respectively. With a full-scale input of 19.99 mv in the low millivolts mode and an amplifier gain of 300, the output of A1 (p/n 38-64) will be 5.997 volts. Thus, after preamplification, the scaling of the unknown input voltage is 3 mv/digit to be displayed.

An input filter, consisting of R2, R4, C3 and C4 on the Amplifier Assembly is activated by switching in the filter switch (S1), mounted on the front panel. The input filter gives 60 db of rejection at 60 Hz.

SIGNAL CONDITIONING FOR VOLTS DC MEASUREMENT (Figure 3-2)

The volts DC mode has three ranges of 19.99, 199.9 and 1000 volts full scale. An attenuator divides the input voltage by 100 in the 19.99-volt range, 1000 in the 199.9-volt range and 10,000 in the 1,000-volt range.

The gain of the input buffer amplifier A1 (p/n 38-64) is set at X30 by the feedback network consisting of R14, R28, R30, and R32. The voltage applied to the X-3 input is scaled by the DC Voltage Input Attenuator and the output of the Buffer Amplifier will increase three millivolts for every digit appearing in the readout.

SIGNAL CONDITIONING FOR CURRENT MEASUREMENTS (Figure 3, 4, & 5)

Current measurements are made with the

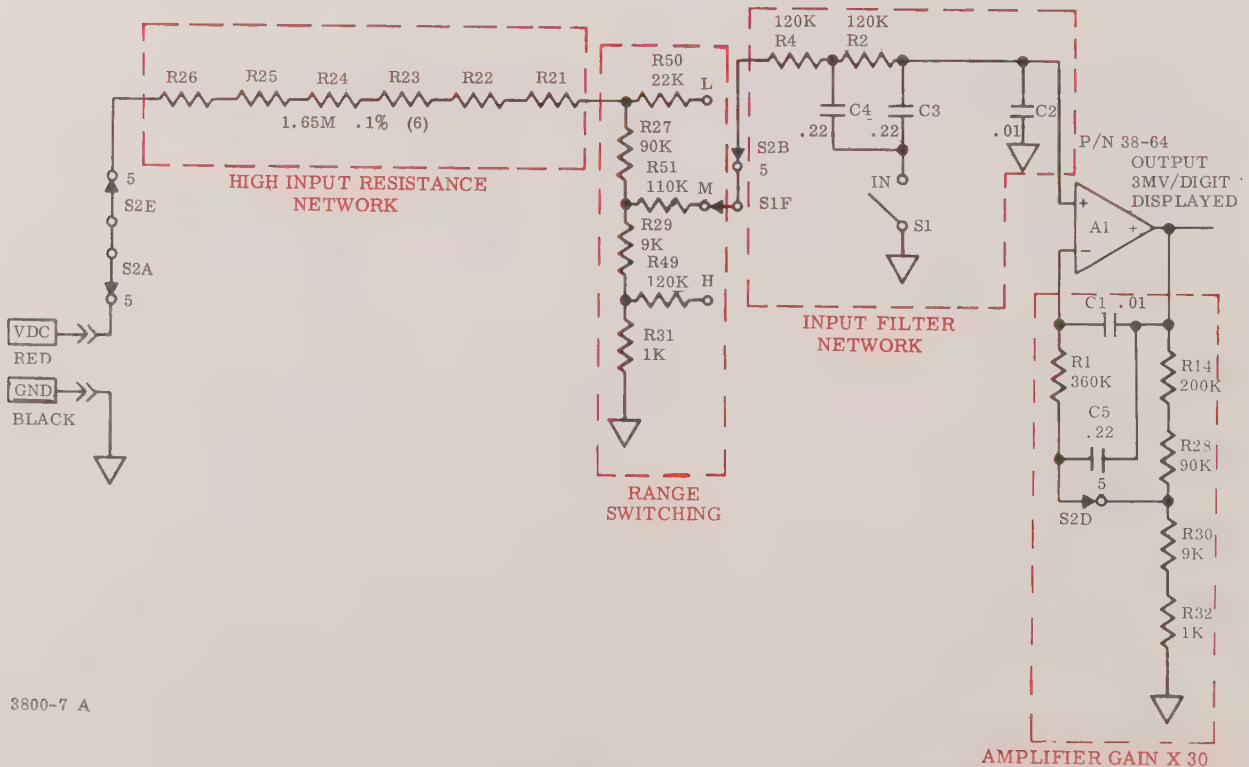


Figure 3-2. Signal Conditioning for Volts DC Measurement

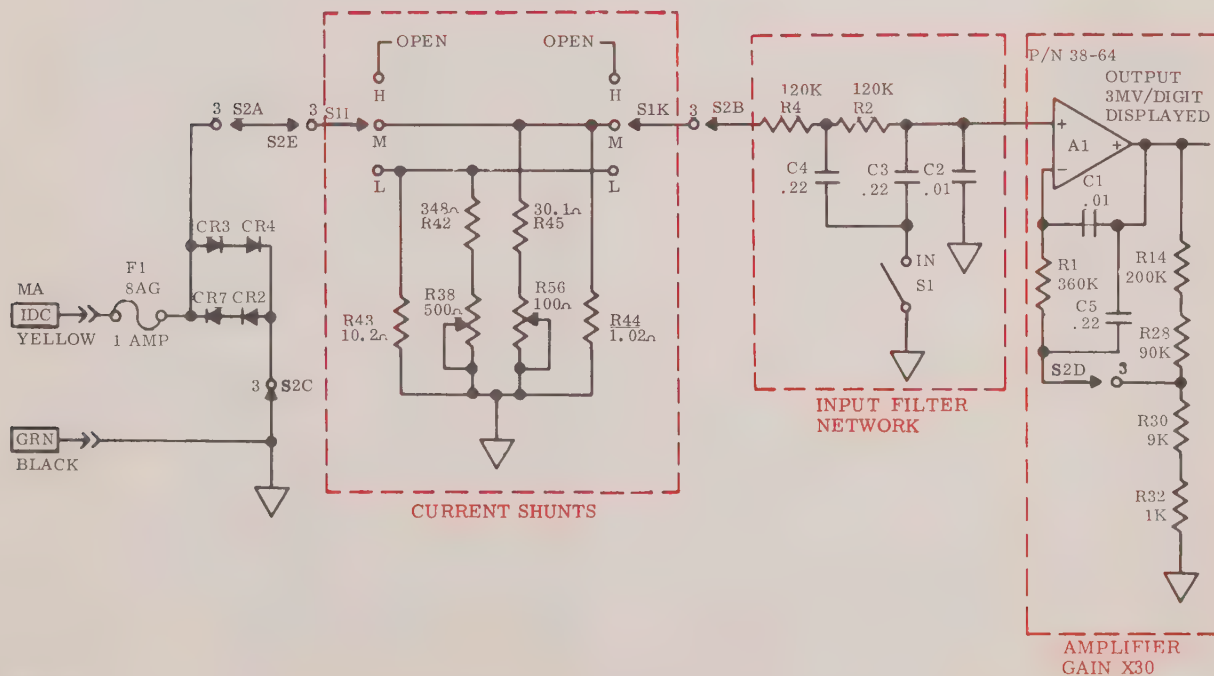
Series X-3 by sensing the voltage drop across a precision resistor switched in series with the unknown current. The current sensing resistor in the milliampere medium range (M) is 1Ω . At full scale this provides a voltage drop of 199.9 millivolts at the input to the buffer amplifier which has a fixed gain of X30. Input scaling of the signal by the buffer and associated circuitry is the same as the other functions and provides 3 mv/digit at the output of buffer amplifier A1 (p/n 38-64). In the milliamperes, low range position (L), the resistor becomes 10Ω to provide the same full-scale voltage drop of 199.9 millivolts. Sensing resistors continue to increase in value by a factor of 10 as the current ranges decrease by factors of 10. However, in nanoampere ranges, the full-scale voltage drop is 19.99 millivolts rather than 199.9 millivolts and the gain of the buffer amplifier is increased to X300 to

avoid using a sensing resistor of unreasonably high value. With a full scale voltage drop of 19.99 and an amplifier gain of X300, the scaling factor at the output of amplifier A1 is maintained at 3 mv/digit displayed.

SIGNAL CONDITIONING FOR VOLTS AC MODE (Figure 3-6)

Series X-3 measures AC voltages from 20 Hz to 700 M Hz with an AC probe utilizing AC coupling and a thermionic diode. A front panel AC zero control is used to nullify diode contact potential. An input attenuator divides the VAC input into full-scale ranges of 19.99 VAC, 199.9 VAC and 1999. VAC (maximum voltage on the high range is 300 VAC).

The input voltage to the buffer amplifier A1 is scaled to 199.9 millivolts (full-scale) by



3800-8 A

Figure 3-3. Signal Conditioning for Milliampere Measurement

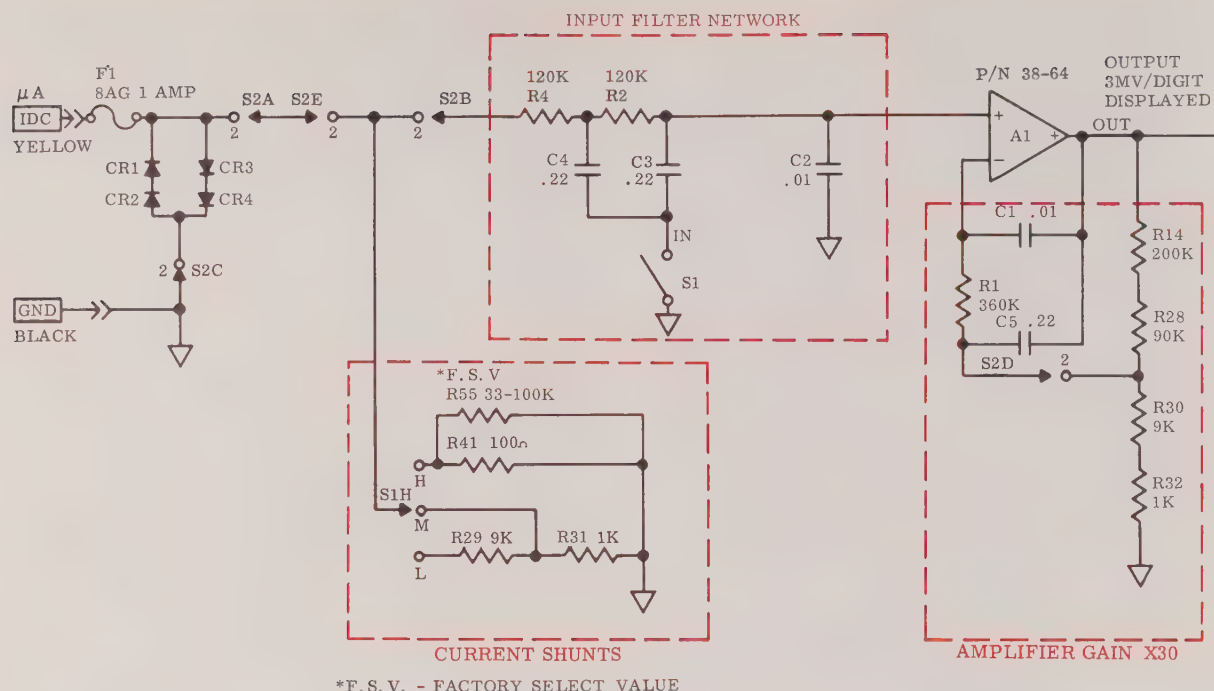


Figure 3-4. Signal Conditioning for Microampere Measurement

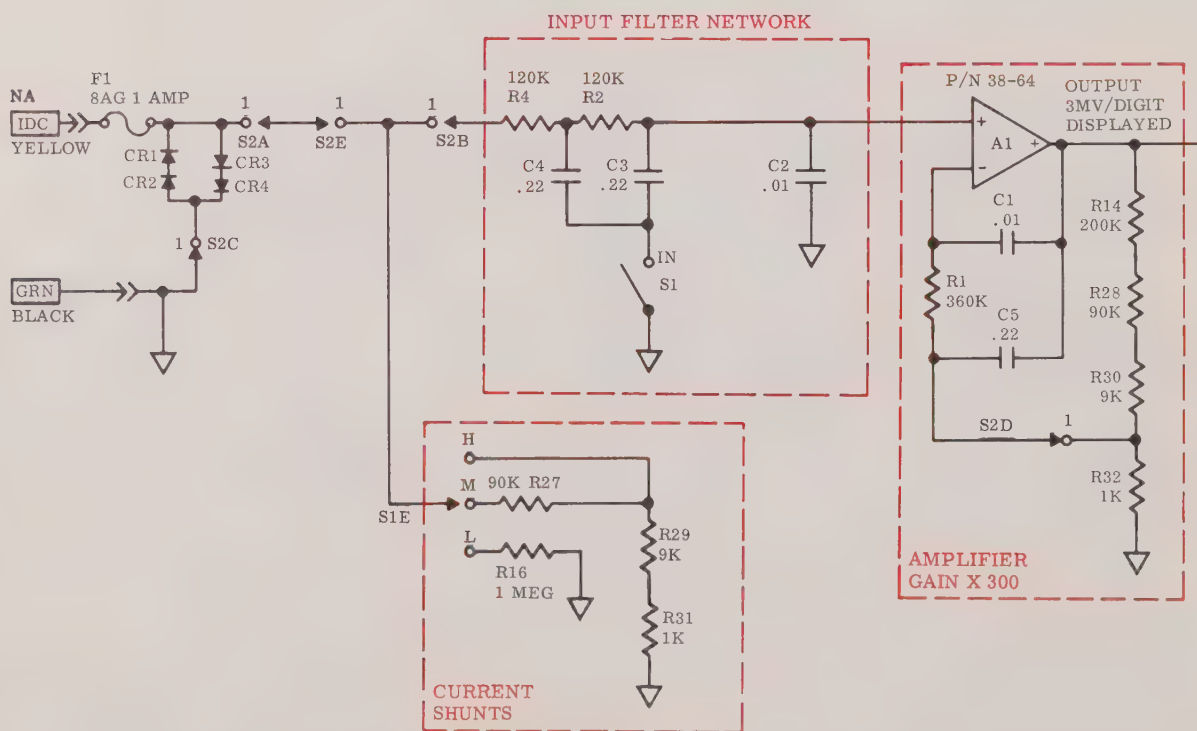


Figure 3-5. Signal Conditioning for Nanoampere Measurement

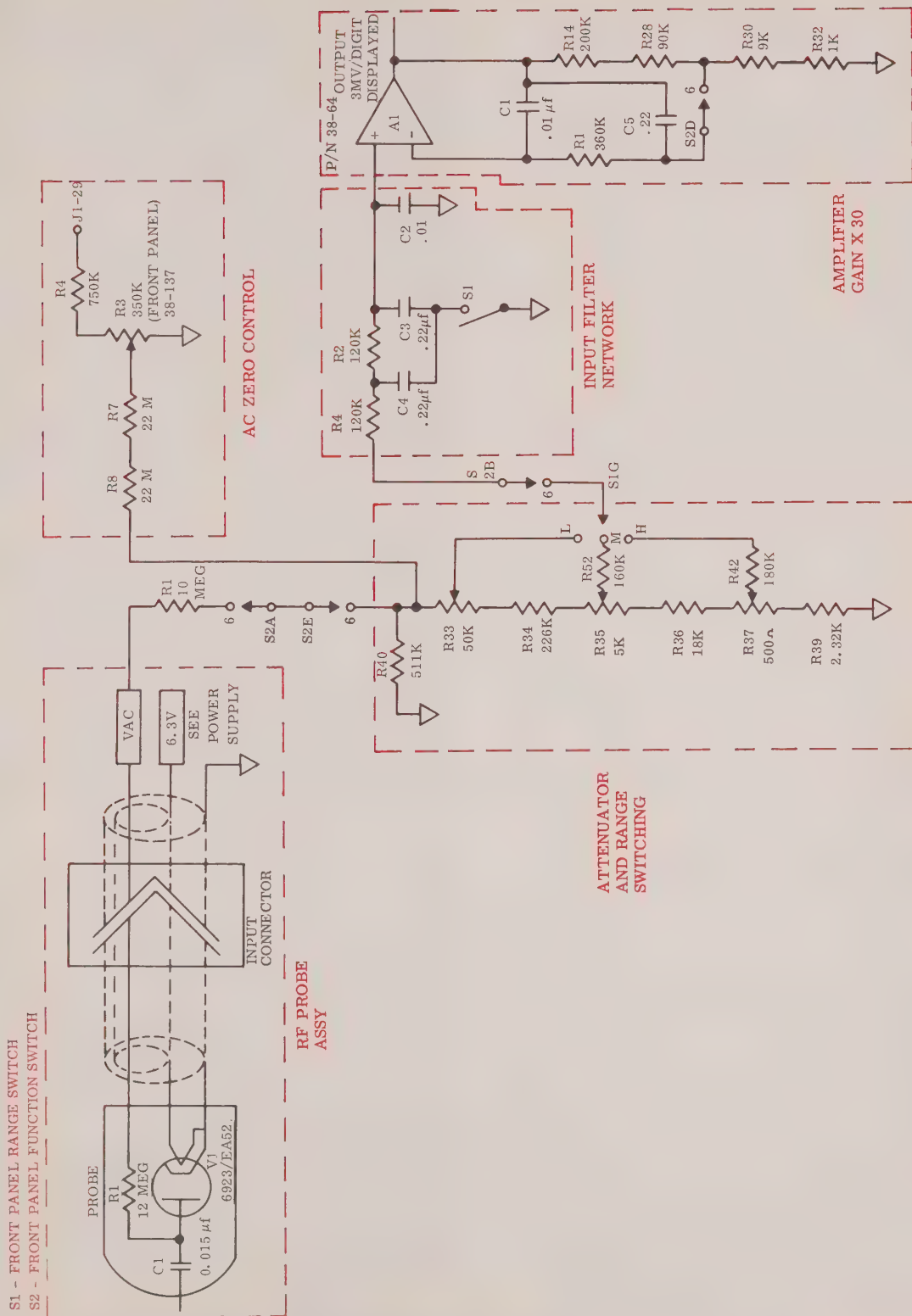


Figure 3-6. Input Probe and Attenuator Board Signal Conditioning for VAC Measurement

each of the attenuator steps and the gain of A1 is set at X30. The scaling and conditioning at the output of A1 is 3 millivolts per digit displayed.

A vacuum tube diode is used in the probe assembly as a rectifier because of its superior high frequency and high voltage (300 v rms max.) performance. The tube filament is energized by a regulated 6.3-volt DC source to eliminate power line interference and to provide good zero stability. The probe is of coaxial design with the diode, a capacitor and resistor located in the probe tip. A phone plug at the end of a double-shielded coaxial cable connects the probe to the X-3. High input resistance (12 MEG Ω) and low shunt capacitance (3 pf) minimize circuit loading.

The probe circuit acts as a negative clamp. The input voltage will have its positive excursion clamped to ground without materially affecting the waveform. The purpose here is to establish a DC voltage component proportional to the positive peak above average value of the input. This action results in a DC voltage at the junction of the diode anode and resistor R1 which is negative with respect to ground. The AC component of the input is removed by the input filter (S1) which must be in the circuit.

SIGNAL CONDITIONING FOR RESISTANCE MEASUREMENTS (Figures 7, 8, & 9)

Resistance measurements are made by measuring the voltage drop across a resistor under test (R_x) through which a known stable current is passing (Figure 3-7).

To read the proper value, current passing through R_x must be properly switched so that one unit of the resistance being measured is equal to one digit displayed in the readout.

To accomplish this one-to-one relationship, the current is changed in precise decade steps depending on the range in use (i. e. 10 ma, 1 ma, 0.1 ma, etc).

The internal current source is composed of a regulated voltage power supply and a series precision resistor. This precision resistor is different for each range and is changed by the range switch, (S1). The regulated voltage supply consists of A1 (TD401) which forms a differential amplifier, and transistor Q1 which is a series regulator. The output of Q1 is adjusted by R2, a 5K Ω potentiometer, which is part of a voltage divider connected to the +85 volts reference supply. Any change in the reference voltage will be cancelled by a corresponding change of current through the test resistor.

Because R_x is in series with the precision resistor in the constant current source (Figure 3-7), a change in the value of R_x will tend to change the current through R_x , even though the precision resistor is much larger than R_x . A change in current will produce an inaccurate reading. To maintain a stable current with various values of R_x ,

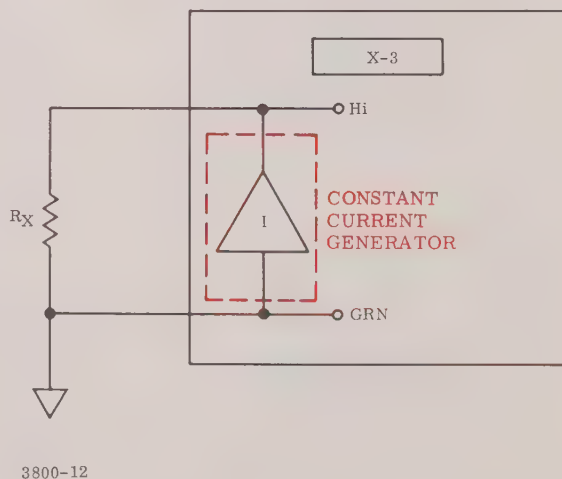
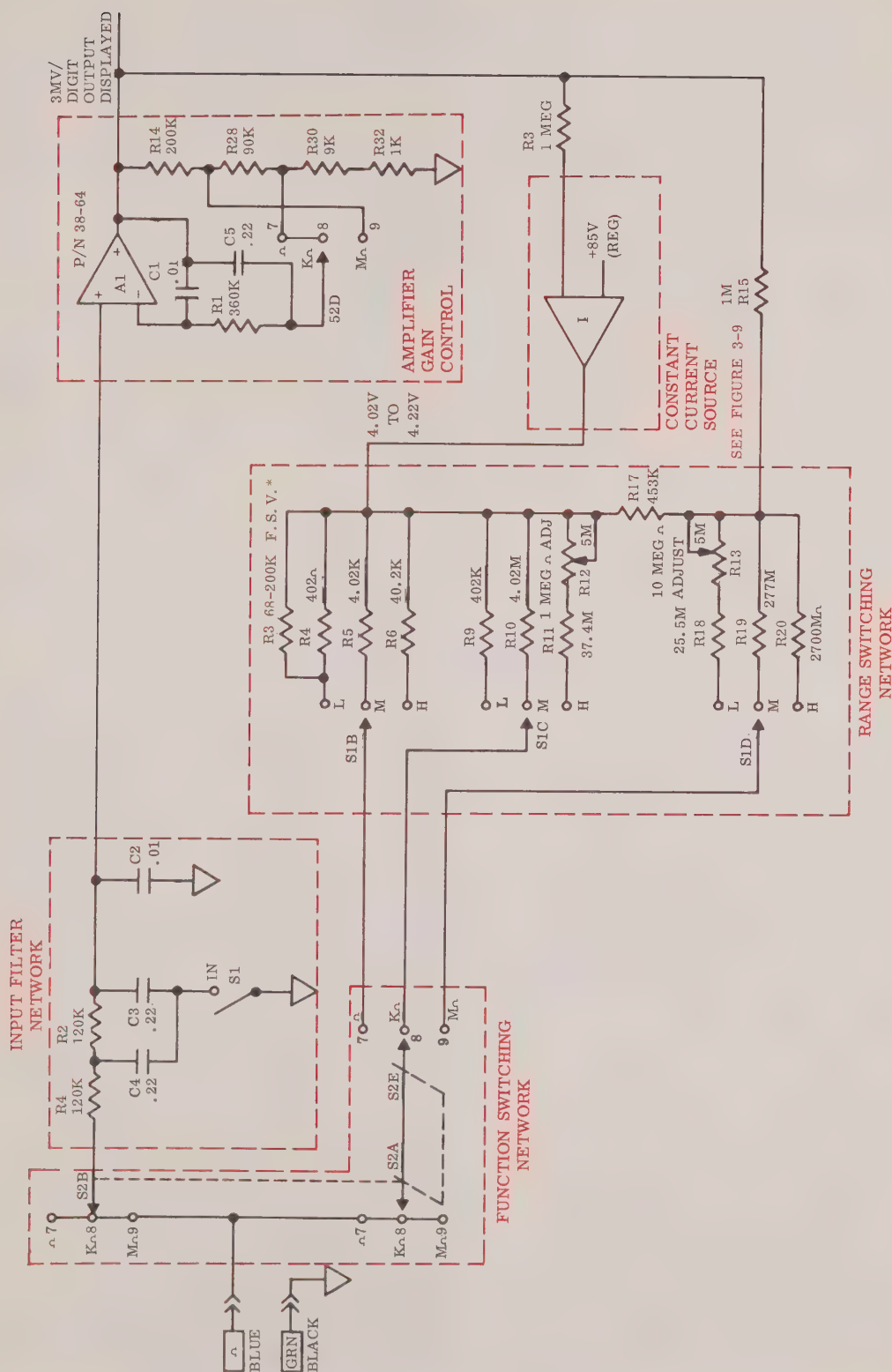


Figure 3-7. Simplified Diagram, Resistance Measurement



* F. S. V. - FACTORY SELECT VALUE

Figure 3-8. Signal Conditioning for Resistance Measurement

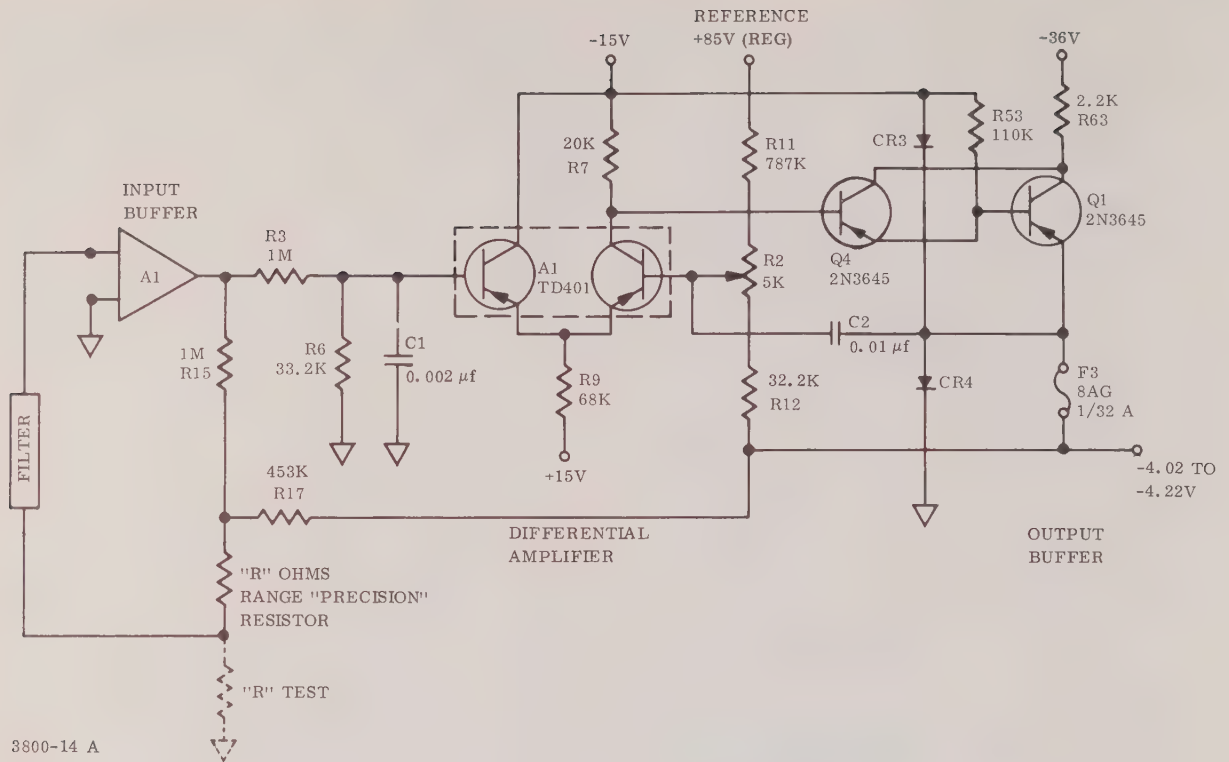


Figure 3-9. Constant Current Source

a resistor network (R3, R6, R16, and R15) is employed to sum together the outputs of the buffer amplifier (A1) and the differential amplifier portion of the constant current source. The values in this resistor network are selected so that any increase in R_x will also increase the voltage source output, thus keeping the current through R_x the same. This true constant current assures precise, linear readings of R_x .

DIGITIZING SECTION (Figure 3-10)

The normalized signal from the attenuator section enters the digitizing section in the form of a DC voltage having an amplitude of 3 mv for each digit displayed in the readout. A block diagram of the digitizing section is shown in Figure 3-10. The input to this section is labelled 'from buffer amplifier output' in Figure 3-10. When the readout dis-

play is +1000 this signal will be +3 volts; when the readout display is -1000 the signal will be -3 volts.

A minus polarity input signal is fed directly to the comparator amplifier (A3). A positive polarity input signal is inverted by a polarity inverting amplifier (A2) causing the comparator amplifier (A3) to see only negative input signals.

To make a reading with the X-3, the signal coming into the comparator amplifier (A3) from the attenuator must be balanced or cancelled out by a feedback signal from the Digital-to-Analog (D/A) Feedback network. A difference between the input signal and the feedback network generates UP- or DOWN-pulses that drive the feedback network so as to reach a balance between the two signals. The output of the comparator amplifier (A3) feeds through two channels (UP- or DOWN-

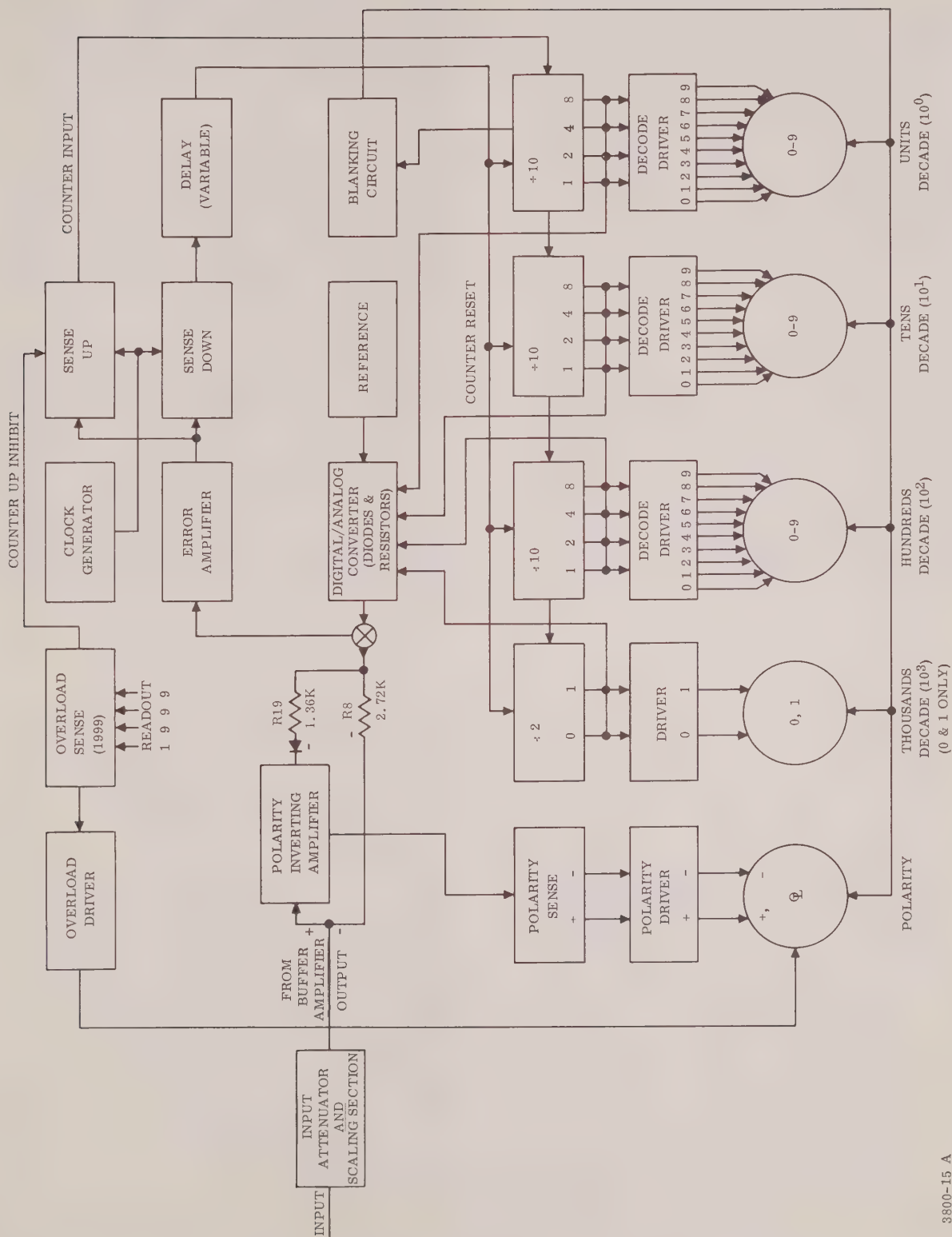


Figure 3-10. Block Diagram, Digitizing Section

drive). UP- pulses are fed into the input of the least significant decade (10^0) and make the D to A feedback network count up. UP- pulses continue to step the right-hand decade digit-by-digit until a nine is reached whereupon the decade returns to zero and transfers a pulse into the next significant decade (10^1) and so on until a balance, or 1999 overload is reached. This digit-by-digit counting also changes the readout display, which is controlled by decade drivers.

DOWN-pulses are delayed by routing them to a variable delay controlled by a display control pot on the front panel. As the ON DISPLAY potentiometer is rotated clockwise, the delay is lengthened to a maximum of about two seconds. The first DOWN-pulse triggers the delay circuit. At the end of the delay period, the D to A network is reset to zero. With all counters and the bridge set to zero, there is now an UP-pulse condition

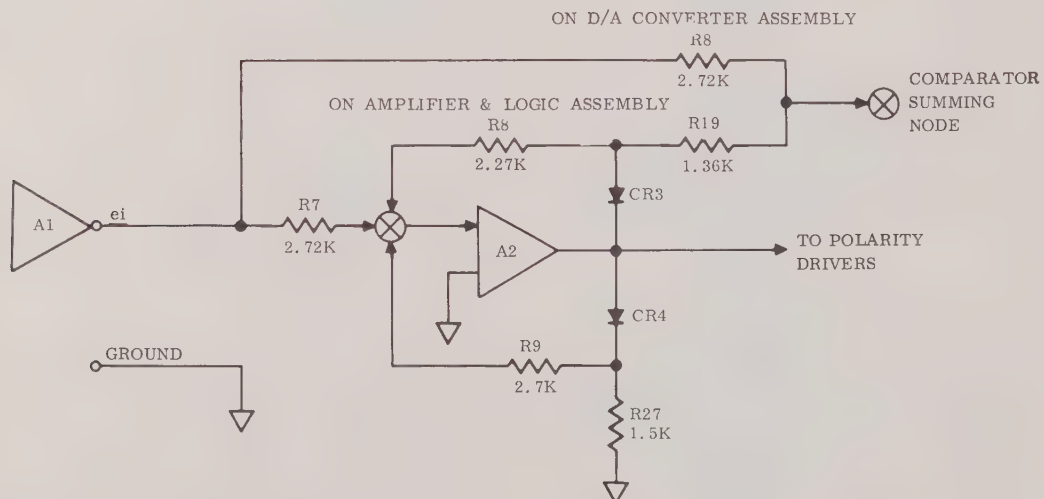
and the instrument counts up to the new reading. The clock operates at 25 KHz or 40 microseconds per bit. A full scale input of 1999 will take about 80 milliseconds to reach a reading.

During the UP-count period, the blur of numbers is eliminated through the use of a blanking circuit. The blanking circuit consists of a series of buffers and a rectifier to sense the counter is running and to shut off the B+ to the NIXIE tubes.

When a 1999-condition exists in the readout, a sensing circuit turns on the overload indicator (Q) and simultaneously shuts off the UP-pulses.

POLARITY SENSING (Figure 3-11)

The polarity sensing circuit furnishes a negative signal to the comparator summing node



3800-16 A

Figure 3-11. Polarity Sensing Circuit

for either a positive or negative input signal. For negative inputs, the signal is routed to the comparator summing node. For positive signals, the input is inverted in a polarity inverting amplifier (A2).

Automatic polarity switching uses a DC operational amplifier for signal routing.

With a positive input ($+e_i$), the output of A1 will be negative and current ($+i$) flows through resistors R7 and R8 (Amplifier and Logic Assembly) as shown in Figure 3-11. This current ($+i$) causes a voltage drop across R8 (Amplifier and Logic Assembly), equal to $+e_i$ but opposite in polarity. The voltage drop causes a current to flow through resistor R19, out of the comparator amplifier (A2) summing node. At the time, $+e_i$ causes a current to flow into the comparator summing node through Resistor R8 (D/A Converter and Reference Assembly). Be-

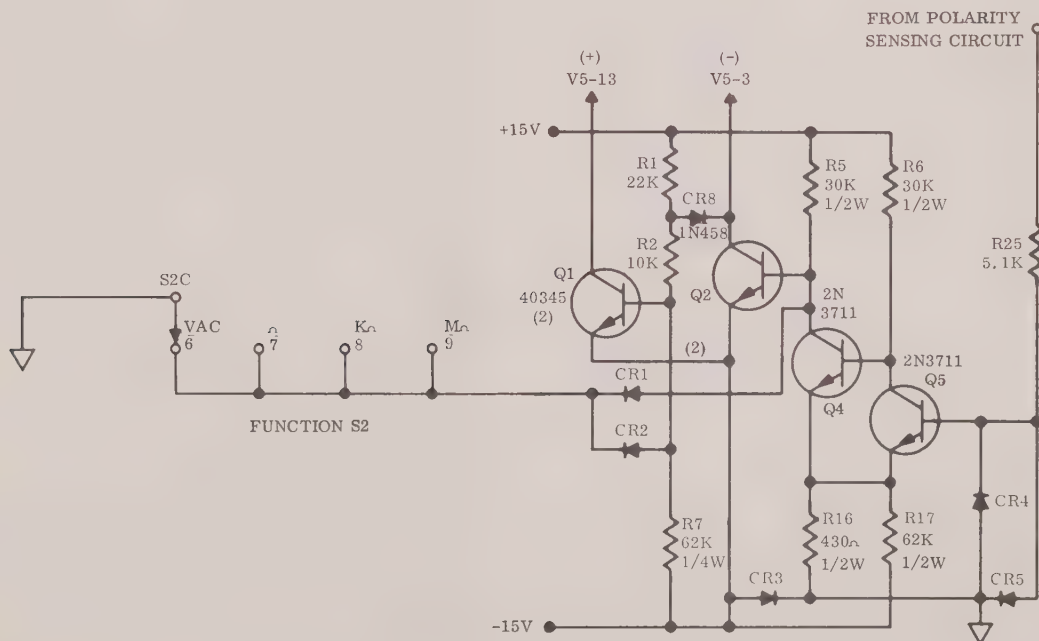
cause the value of R8 (D/A Converter and Reference Assembly) is twice the value of R19, the net effect is to cause a current to flow out of the comparator summing node with a positive signal input.

When there is a negative input ($-e_i$), the output of A2 will be positive and diode CR3 is reverse biased and cut off. Therefore, no current will flow through R19 into the comparator summing node.

POLARITY DRIVERS (Figure 3-12)

The output of Amplifier A2 in the polarity sensing circuitry is applied to transistor circuitry which energizes the positive and negative polarity symbols in the readout.

As current flow through R25 increases in a positive direction, a trigger circuit consisting of transistors Q4 and Q5 changes state



3800-17 A

Figure 3-12. Polarity Driver Circuitry

to turn on transistor Q2 to energize the minus NIXIE symbol in the readout. Because polarity amplifier A2 inverts the DC input, the symbol is correct.

When the DC signal input voltage become positive, the trigger of circuit changes state causing Q2 to turn off (-NIXIE) and Q1 to turn on energizing the positive polarity NIXIE.

In those functions where polarity indication is not needed (VAC, Ω , K Ω , M Ω), level "C" of the function switch ties the base of Q1 and Q2 to ground ensuring no indication.

REACHING A READING

The way an X-3 arrives "at Balance" when measuring its input is controlled by the condition at the comparator summing point. The net current from the polarity sensing circuit is summed with feedback current from the D/A converter at the comparator summing node. When the two currents are equal, balance has been achieved. An unbalance exists when the readout displays a voltage different from the actual input voltage. In the unbalanced condition, the two currents at the comparator summing node are unequal. The comparator output is then applied to the input of threshold detection circuits and UP-DOWN logic which precede the counting decades.

SN7400N Quad nand gates are used for logic and timing functions in the X-3 Series. 7400 logic is defined as follows:

Low Voltage = Logical 0

High Voltage = Logical 1

Supply voltage to the chips is a nominal +5V DC. A high "1" input is required at both the input terminals of a gate to produce a logical "0" level at the output. Schematics of the internal circuitry of the gates of the SN7400 Quadruple Assembly, SN7490 Decade Count-

er, and SN7441 BCD-to-Decimal Decoder are shown in Figure 3-13, 3-14, and 3-15, respectively.

DIGITAL SECTION, GENERAL OPERATION (Figure 3-16)

The comparator output at the emitter of Q8 is zero when the DVM is at balance, positive when the input is greater than the A-to-D feedback network and negative when the input is less than the A-to-D feedback network. The positive DC error signal is modulated by the clock at gate A4-A. Gates A4-A, A4-B, and A4-C, detect the positive error signal level and produce a series of UP-pulses, driving transistor Q16 and applying pulses to the input of least significant decade A4 (Pin 14) in the D-to-A converter section. The action continues, pulling in bridge resistors in a 1-2-4-8 format, until the bridge current equals the input current. The balanced current condition causes the error signal at

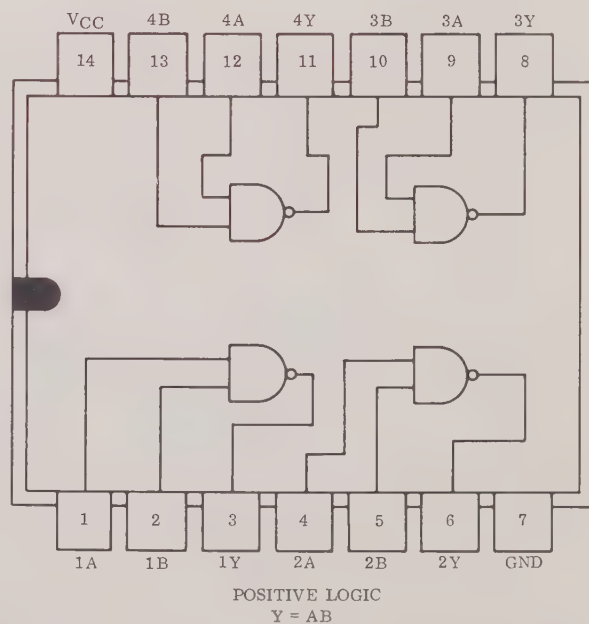


Figure 3-13. Type SN7400N Quadruple 2-Input Positive Nand Gate

TRUTH TABLES

BCD COUNT SEQUENCE (SEE NOTE 1)

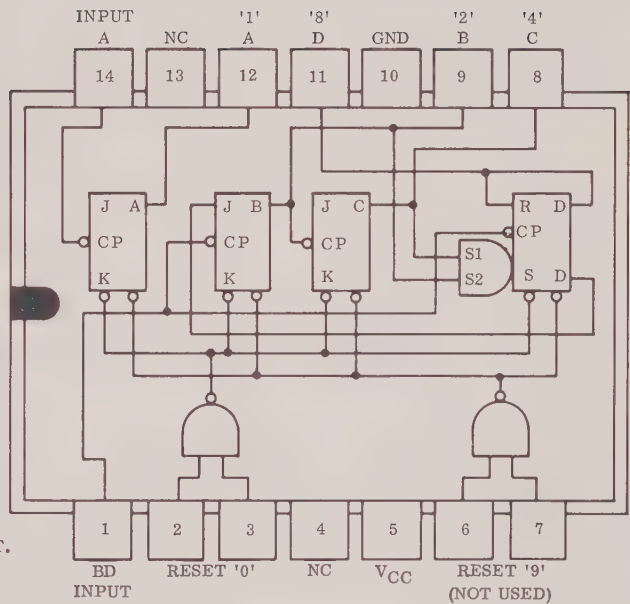
COUNT	OUTPUT			
	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

RESET/COUNT (SEE NOTE 2)

RESET INPUTS				OUTPUT
R ₀₍₁₎	R ₀₍₂₎	R ₉₍₁₎	R ₉₍₂₎	
1	1	0	X	0000
1	1	X	0	0000
X	0	1	1	1001
0	X	1	1	1001
1	1	1	1	1001
X	0	X	0	COUNT
0	X	0	X	COUNT
0	X	X	0	COUNT
X	0	0	X	COUNT

NOTES:

1. OUTPUT A CONNECTED TO INPUT BD FOR BCD COUNT.
2. X INDICATES THAT EITHER A LOGICAL 1 OR A LOGICAL 0 MAY BE PRESENT.



POSITIVE LOGIC

SEE TRUTH TABLES

NC-NO INTERNAL CONNECTION

3800-19 A

Figure 3-14. Type SN7490N Decade Counter

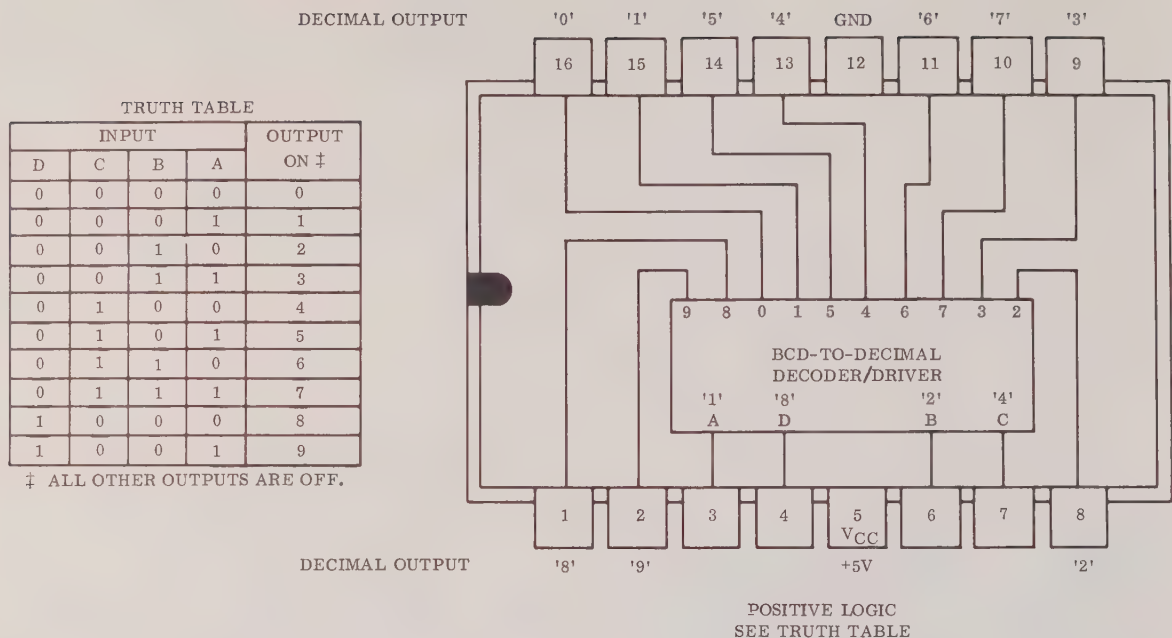


Figure 3-15. Type SN7441AN BCD-Decimal Decoder/Driver

Pin 6 of A3 (comparator amplifier) to be either zero or equivalent to less than one digit. At this time, the input to gate A4-D at pin 5 is below the threshold level and no further "up" count pulses are produced.

When the input is negative, the negative signal is inverted by gate A4-D and modulated by the clock at gate A5-C producing down-pulses. The output of gate A5-C triggers a one-shot multivibrator. The one-shot multivibrator determines how long the DVM holds the reading. By means of the ON DISPLAY potentiometer located on the front panel, the reset delay period can be adjusted (R1 in Figure 3-16) from 60 ms to 2 seconds. At the end of the delay period, a reset signal zeros the counting decades and the over-range flip-flop. The error signal at the output of the comparator amplifier A3 then becomes positive and results in UP-counts

until the instrument arrives at a balance.

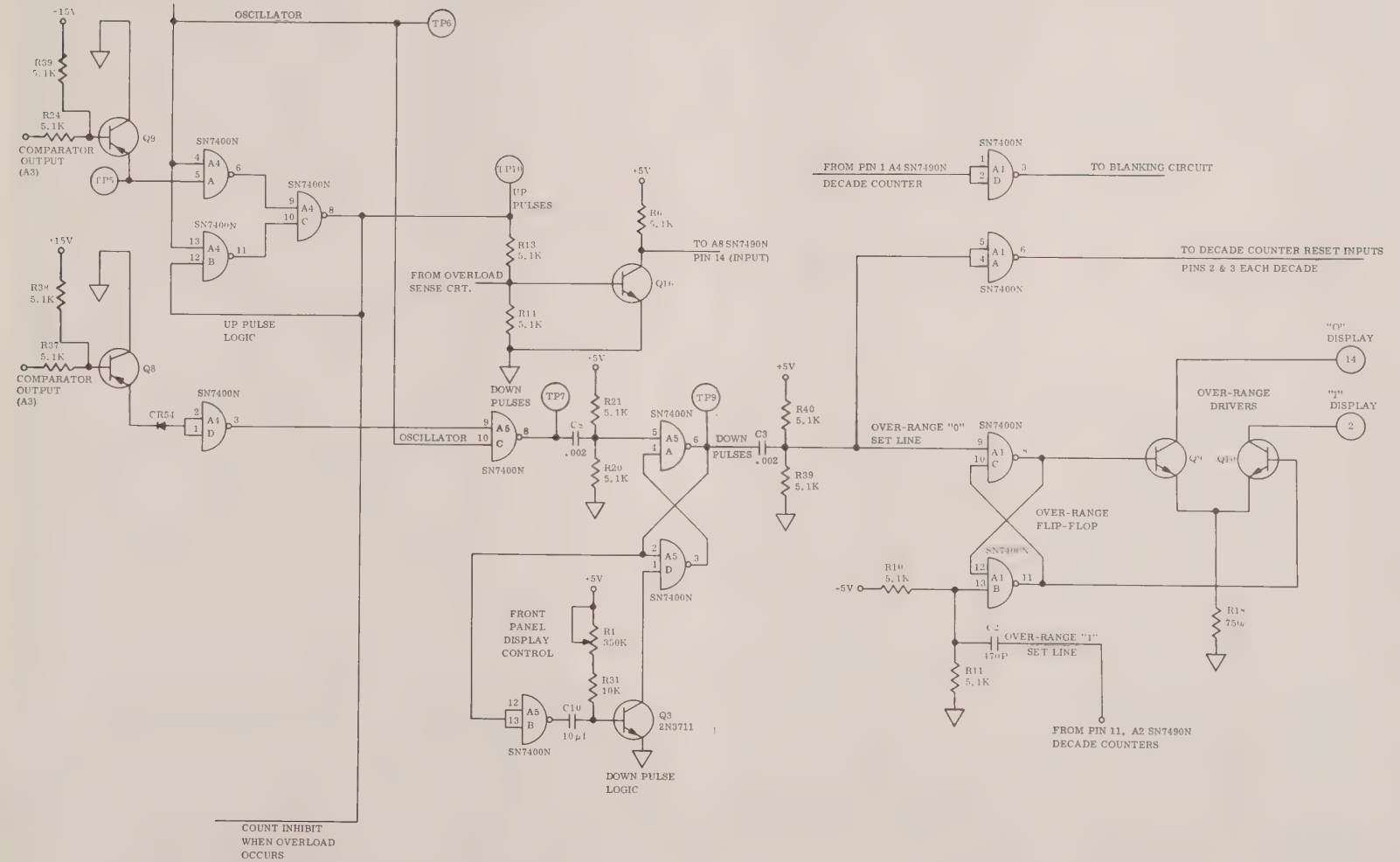
CLOCK PULSE GENERATOR (Figure 3-17)

The Clock pulses for the X-3 are generated by the astable stage formed by transistors Q2 and Q1 on the Main Board. The output of this astable stage is buffered by Q4, an emitter follower into A4 Pin 4 and 13, and A5 Pin 10. The output waveform of the Clock Pulse Generator may be monitored at TP6.

OVERLOAD SENSE CIRCUITRY (Figure 3-18)

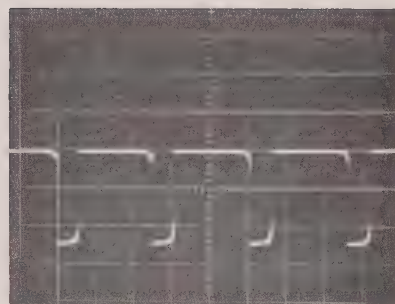
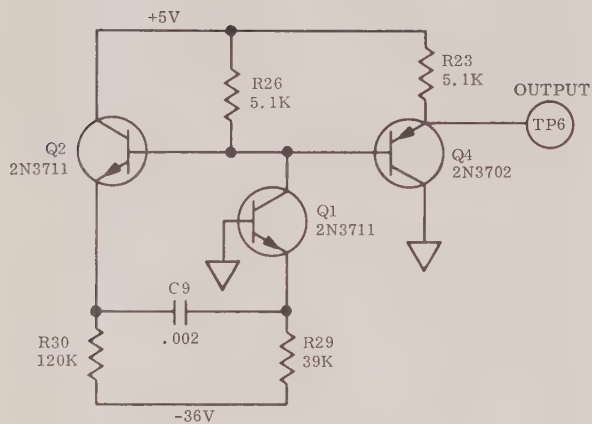
When the readout displays the maximum reading in over-range or 1999, transistor Q17 is gated "on", biasing Q3 "on" and lighting the overload display in the readout (Q). Q16, the UP-pulse buffer is also biased on, disabling the UP-pulse channel. Transistor Q10 (Switch 1) is typical of "switches" S-2, S-3, and S-4.

NOTES



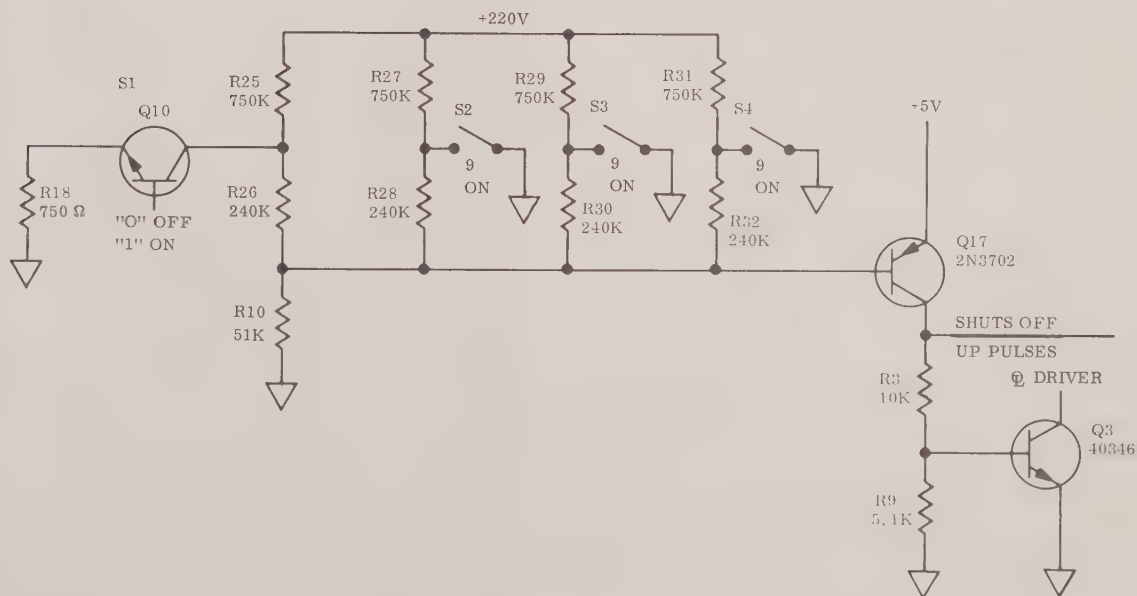
3800-21 A

Figure 3-16. Up-Down Digital Logic



3800-22 A

Figure 3-17. Clock Pulse Circuitry



3800-23 A

Figure 3-18. Overload Sense Circuitry

NOTES

Figure 3-19. DVM Schematic Diagram

CHAPTER IV

CALIBRATION AND MAINTENANCE

CALIBRATION

In the calibration instructions provided in this chapter, it is assumed that the instrument is in good working order and only requires calibration. If any components are defective, it may be difficult, if not impossible, to calibrate the instrument. If problems are encountered while performing the calibration procedures (i.e. the instrument will not meet the requirements set forth in the steps of the procedures), refer to the troubleshooting paragraph in this chapter.

EQUIPMENT REQUIRED

1. A voltage standard between 10 MVDC and 1000 VDC.
2. A current source between 10 nA and 150 mA.
3. An audio voltage standard between 10 VAC, 400 Hz and 300 VAC, 400 Hz.
4. An ohms standard between 10Ω and 15 Meg Ω .
5. An oscilloscope, Tektronix Model 502, or equivalent.
6. A Voltmeter capable of measuring 6.3 VDC.
7. An extension board, NLS P/N 1009-41.

NOTE

It should be noted that the error in making a measurement with the Series X-3 DVM can be as much as the stated accuracy of the instrument plus the accuracy of the standards used in its calibration.

INITIAL PREPARATION

1. Remove the two screws on each side of cover and remove cover.
2. Remove Amplifier and Logic Assembly from instrument.
3. Insert extension board into J3 of Main Board Assembly.
4. Mount Amplifier and Logic Assembly on top of extension board by inserting amplifier and logic board pins into extension board. Use care to ensure proper pin alignment.
5. Plug power cord into 115 VAC, 50-400 Hz, single phase power source.
6. Turn ON DISPLAY control clockwise until an audible click is heard. Allow 30 minutes for instrument warm-up.
7. In each step, as applicable in the following procedures, allow warm-up time for each item of test equipment as per manufacturers requirements.

PROCEDURE

1. Place ON DISPLAY potentiometer on front of instrument (right-most potentiometer) in center of its travel.
2. Place a voltmeter between 6.3V source (Figure 4-1) and signal LO input connector (black). Check to ensure that voltmeter indicates an input of 6.3 VDC $\pm 8\%$.
3. Place range switch of instrument in H position.
4. Place function switch of instrument in mV position.

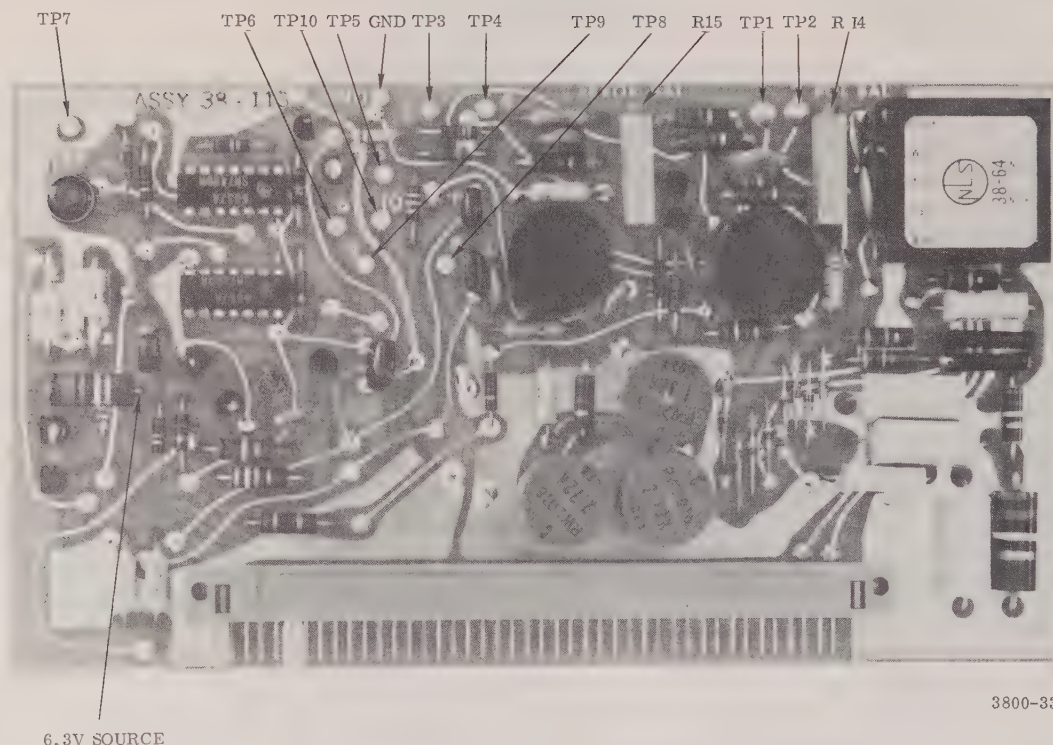


Figure 4-1. Amplifier and Logic Assembly Adjustments and Test Points

5. Connect input cables to connectors on front of instrument as follows (connectors are labeled on front panel):

Red Cable.....	HI
Black Cable.....	LO
Black Cable (with probe) .	AC PROBE
6. Connect input leads of oscilloscope to ANALOG OUTPUT connectors on rear of instrument.
7. Set oscilloscope sensitivity to 1 MV/CM. Oscilloscope should not be isolated from earth ground.
8. Connect red and black input leads together.
9. Set R14 and R15 fully counterclockwise (Figure 4-1).
10. Rotate DC and OHMS ZERO potentiometer on front of instrument (center potentiometer) until oscilloscope indicates a zero reading.
11. Connect input leads of oscilloscope to TP2 of Amplifier and Logic Assembly, 38-113 (Figure 4-1), and black analog output terminal.
12. Set oscilloscope sensitivity to 1 MV/CM and observe DC level.
13. Change oscilloscope lead from TP2 to TP1 and adjust R14 (Figure 4-1) until oscilloscope shows the same DC level as observed in Step 12.
14. Change oscilloscope lead from TP1 to TP4 and observe DC level.
15. Change oscilloscope lead from TP4 to TP3 and adjust R15 (Figure 4-1) until oscilloscope shows the same DC level as observed in Step 14.

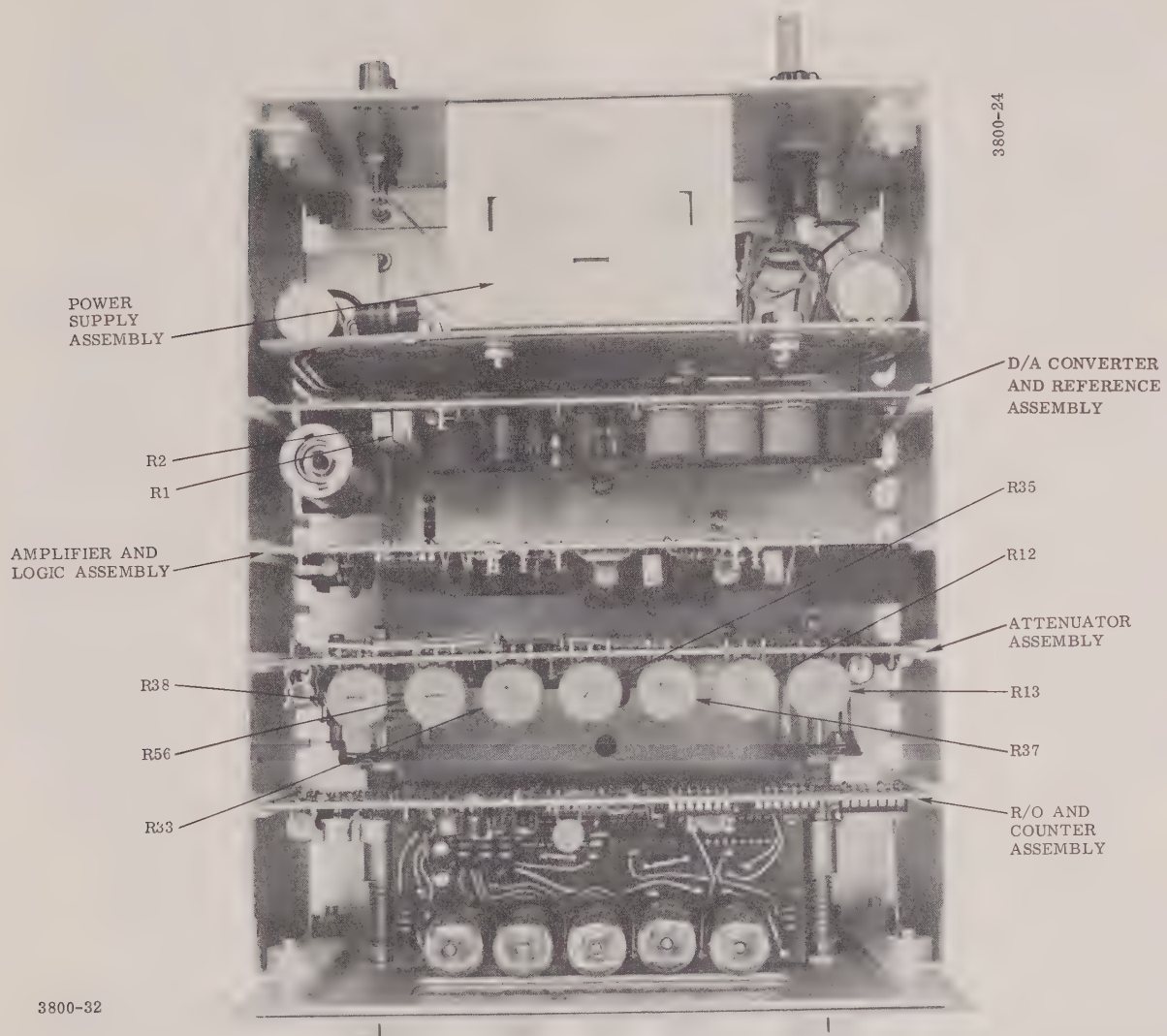


Figure 4-2. DVM Top View

16. Disconnect oscilloscope leads.
17. Connect red and black input leads to voltage standard. Apply approximately 150 mV.
18. Increase and decrease input voltage to see that DVM will count up one digit at a time to plus or minus 10 digits then count down one digit at a time and return to zero. If instrument does not, repeat Steps 6 thru 18.
19. Connect red and black input leads together.
20. Adjust DC and OHMS ZERO potentiometer if necessary until readout displays all zeros.
21. Place range switch in M position.
22. Connect red and black input leads to voltage standard. Apply approximately -150 mV.
23. Reverse polarity of signal input and check to see that the numerical value displayed in readout is identical (± 2 digits), in either polarity, with the same voltage applied.
24. Instructions for range calibration in each mode of operation are contained in Figures 4-3 thru 4-6.
25. When calibration is completed, replace Amplifier and Logic Assembly and cover.

MAINTENANCE

If the instrument is malfunctioning after carefully following the calibration instructions set forth in the preceeding paragraphs, maintenance will be required. The following troubleshooting data should enable the technician to isolate the cause of malfunction and thereby effect the replacement of the defective component/s.

ACCESS TO COMPONENTS

The R/O and Counter Assembly, Amplifier and Logic Assembly and D/A converter and Reference Assembly are plug-in modules, easily removed by lifting them out of their matching connectors in the Main Board Assembly.

The Attenuator Assembly is also a plug-in module but, prior to removal the range switch knob and function switch knob must first be pulled away from the front panel and held away by the insertion of a small block of wood or even a pencil. By this action, the switches' shafts are disengaged from the switches which are located on the Attenuator Assembly.

To gain access to the power supply board assembly components, remove the four screws attaching the rear plate to the transformer, the four screws attaching the rear plate to the sides of the chassis and the two screws attaching the rear plate to the bottom of the chassis. The rear plate may then be lowered and the components are accessible.

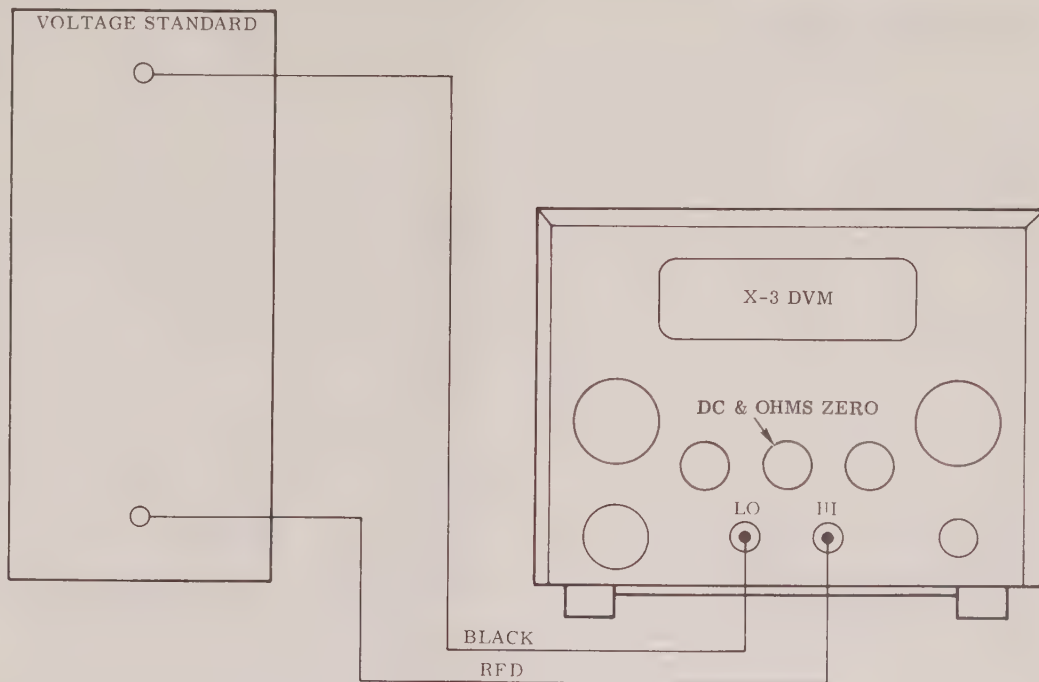
TROUBLESHOOTING

Equipment Required

1. A voltmeter capable of measuring between 50 MVAC & 5 VAC and ± 0 VDC and ± 40 VDC.
2. An oscilloscope, Tektronix Model 502, or equivalent.
3. A voltage standard between ± 1 VDC and ± 5 VDC.

Initial Preparation

1. Remove the four screws attaching the hood to the main chassis.
2. Gently withdraw hood from the instrument's main chassis.
3. Plug power cord into 115 VAC, 50-400 Hz,



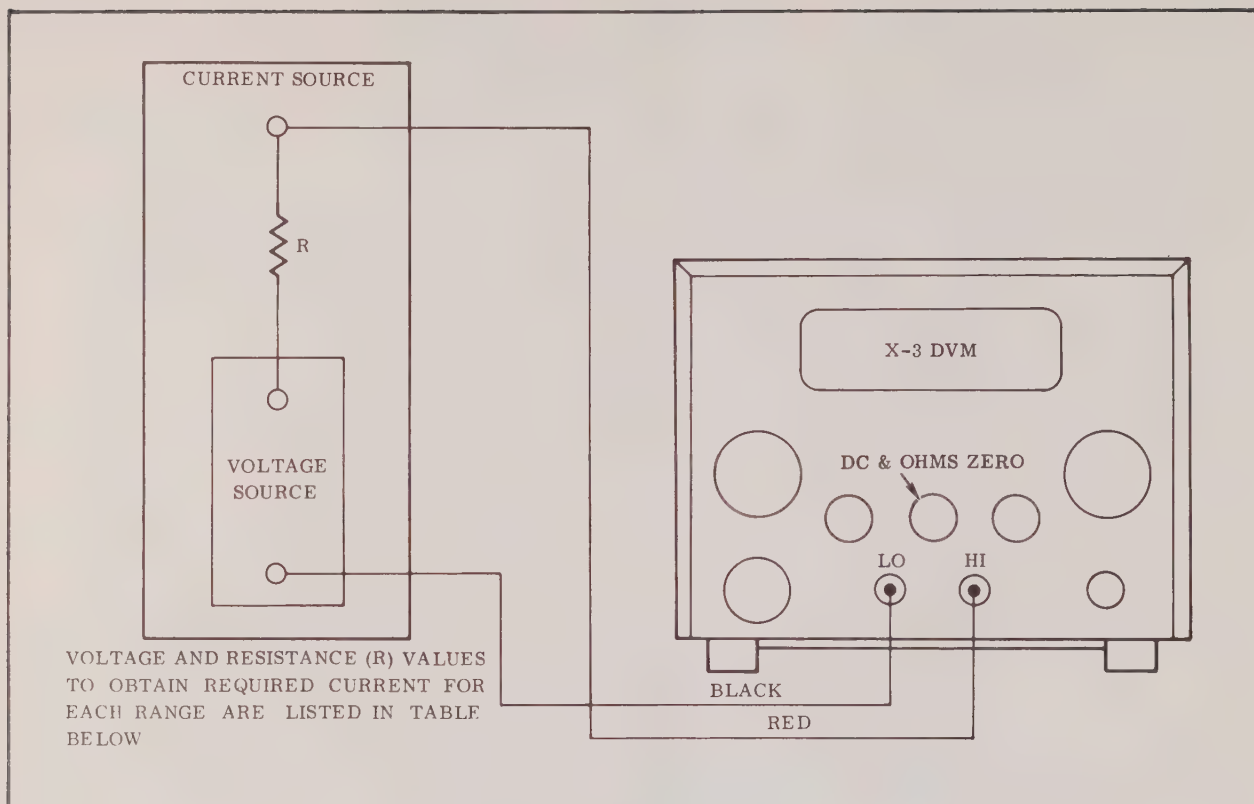
NOTE

PRIOR TO EACH RANGE OR FUNCTION CHANGE, ZERO THE READOUT IN MVDC OR VDC MODE (REFER TO CHAPTER II, ZEROING THE READOUT MVDC or VDC Zero).

PROCEDURE

FUNCTION SWITCH POSITION	RANGE SWITCH POSITION	APPLY APPROXIMATELY	ADJUST	LOCATION (Figure No.)	READOUT TO DISPLAY VOLTAGE APPLIED, WITHIN
mV	H	1500 mV	NONE	---	0.1% RDG + 0.1% F.S.
mV	M	150 mV	R1	4-2	0.1% RDG + 0.1% F.S.
mV	L	15 mV	NONE	---	0.2% RDG + 0.5% F.S.
VDC	L	15 VDC	NONE	---	0.1% RDG + 0.1% F.S.
WARNING HIGH VOLTAGE					
VDC	M	150 VDC	NONE	---	0.1% RDG + 0.1% F.S.
VDC	H	950 VDC	NONE	---	0.1% RDG + 0.2% F.S.

Figure 4-3. MVDC and VDC Calibration



NOTES

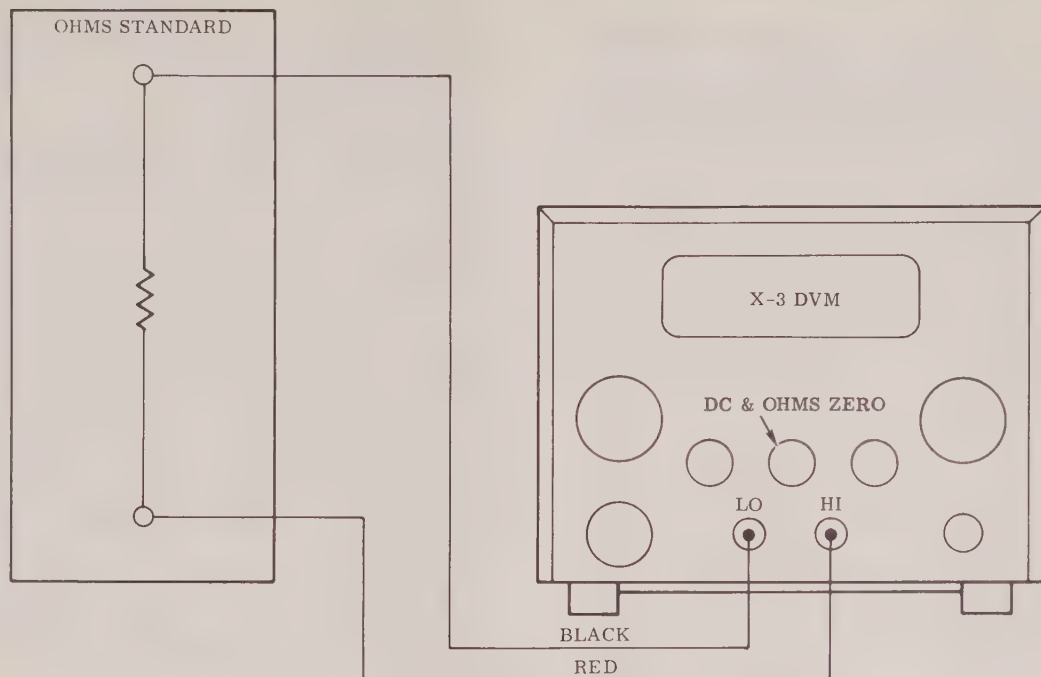
1. INSTRUMENT MUST FIRST BE CALIBRATED IN MVDC AND DC MODES.
2. PRIOR TO EACH RANGE OR FUNCTION CHANGE, ZERO THE READOUT IN THE CURRENT MODE (REFER TO CHAPTER II, ZEROING THE READ-OUT, Current Zero).

PROCEDURE

FUNCTION SWITCH POSITION	RANGE SWITCH POSITION	CURRENT TO BE APPLIED			ADJUST	LOCATION (FIGURE NO.)	READOUT TO DISPLAY CURRENT APPLIED WITHIN	DVM INTERNAL RESISTANCE
			VOLTS ($\pm 0.02\%$)	R ($\pm 0.02\%$)				
nA	L	15 nA	0.165 V	10 M	NONE	---	20% RDG. + 0.5% F.S.	1 M Ω
nA	M	150 nA	1.515 V	10 M	NONE	---	5% RDG. + 0.5% F.S.	100 K Ω
nA	H	1500 nA	1.515 V	1 M	NONE	---	0.5% RDG. + 0.5% F.S.	10 K Ω
μ A	L	15 μ A	15.150 V	1 M	NONE	---	0.2% RDG. + 0.1% F.S.	1000 Ω
μ A	M	150 μ A	15.150 V	100 K	NONE	---	0.1% RDG. + 0.1% F.S.	1 K Ω
μ A	H	1500 μ A	15.150 V	10 K	NONE	---	0.1% RDG. + 0.1% F.S.	102 Ω
mA	L	15 mA	15.150 V	1 K	R38	4-2	0.1% RDG. + 0.1% F.S.	12 Ω
mA	M	150 mA	15.210 V	100 Ω	R56	4-2	0.1% RDG. + 0.1% F.S.	3 Ω

CAUTION: DO NOT APPLY MORE THAN 200 mA or DAMAGE TO THE INSTRUMENT MAY RESULT.

Figure 4-4. Current Calibration



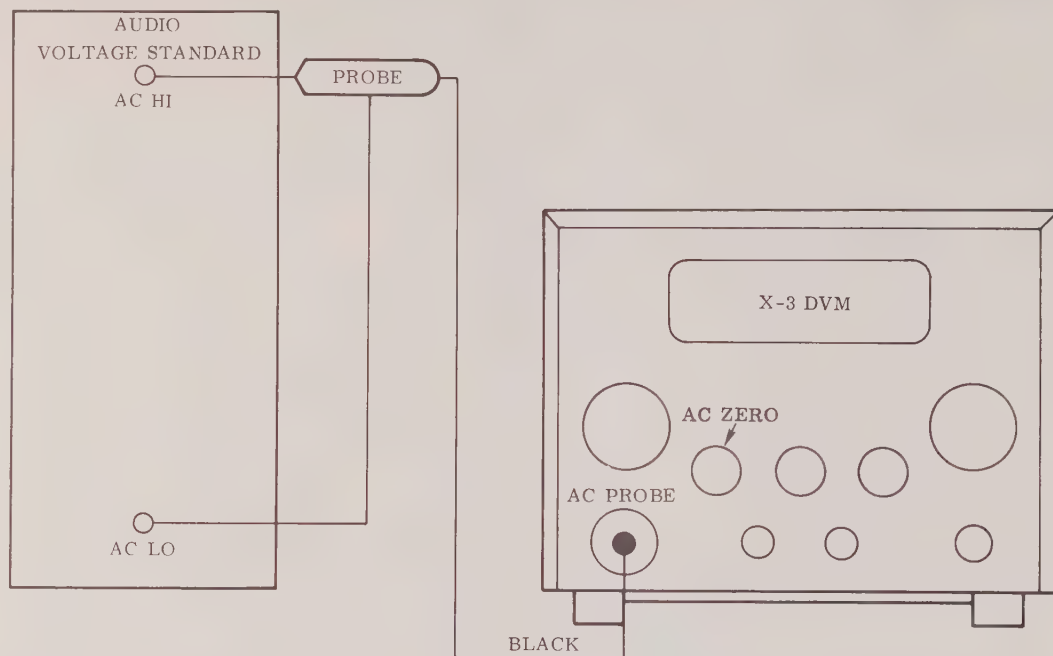
NOTES

1. INSTRUMENT MUST BE FIRST CALIBRATED IN MVDC & DC MODES.
2. PRIOR TO EACH RANGE OR FUNCTION CHANGE, ZERO THE READ-OUT IN OHMS MODE (REFER TO CHAPTER II, ZEROING THE READ-OUT, Ohms Zero).

PROCEDURE

FUNCTION SWITCH POSITION	RANGE SWITCH POSITION	APPLY APPROXIMATELY	ADJUST	LOCATION (Figure No.)	READOUT TO DISPLAY OHMIC VALUE APPLIED, WITHIN
Ω	H	1500 Ω	R2	4-2	0.1% RDG + 0.1% F.S.
Ω	M	150 Ω	NONE	---	0.1% RDG + 0.1% F.S.
Ω	L	15 Ω	NONE	---	0.1% RDG + 0.2% F.S.
K Ω	L	15 K Ω	NONE	---	0.1% RDG + 0.1% F.S.
K Ω	M	150 K Ω	NONE	---	0.1% RDG + 0.1% F.S.
K Ω	H	1500 K Ω	R12	4-2	0.5% RDG + 0.1% F.S.
MEG Ω	L	15 MEG Ω	R13	4-2	1% RDG + 0.2% F.S.
MEG Ω	M	150 MEG Ω	NONE	---	20% RDG + 0.2% F.S.
MEG Ω	H	1500 MEG Ω	NONE	---	USEABLE FOR RELATIVE MEASUREMENTS

Figure 4-5. Ohms Calibration



NOTES

1. INSTRUMENT MUST FIRST BE CALIBRATED IN VDC MODE.
2. ZERO READOUT IN VDC MODE (REFER TO CHAPTER II, ZEROING THE READOUT, MVDC OR VDC Zero).
3. PRIOR TO EACH RANGE OR FUNCTION CHANGE, ZERO THE READOUT IN VAC MODE (REFER TO CHAPTER II, ZEROING THE READOUT, VAC Zero).

PROCEDURE

FUNCTION SWITCH POSITION	RANGE SWITCH POSITION	APPLY APPROXIMATELY	ADJUST	LOCATION (Figure No.)	READOUT TO DISPLAY VOLTAGE APPLIED, WITHIN
VAC	L	15 VAC, 400 Hz WARNING HIGH VOLTAGE	R33	4-2	3% F.S. (0.5V & UP)
VAC	M	150 VAC, 400 Hz	R35	4-2	3% F.S.
VAC	H	250 VAC, 400 Hz	R37	4-2	3% F.S.

CAUTION

DO NOT APPLY MORE THAN
300 VAC OR DAMAGE TO THE INSTRUMENT MAY RESULT

single phase power source (or 230 VAC option).

4. Turn ON DISPLAY control clockwise until an audible click is heard. Allow 30 minutes for instrument warm-up.

Procedure

1. To ensure proper line voltage, fuse operation and functioning power switch, measure the voltage across two of the three rear output connectors (labeled Accessory Power Supply) for PS-1 operation. Value should be approximately 40 VAC.
 - a. If value is not approximately 40 VAC, check line voltage, fuse (F1), power switch (S2) and transformer (T1).
 - b. If value is approximately 40 VAC, proceed to step 2.
2. Check the following voltage supplies: (all to be within 5%):
 - a. +5 VDC - Ripple - 50 MVAC p-p at pin 29 of J3 on Amplifier and Logic Assembly (Figure 5-6).
 - b. +15 VDC - Ripple - 60 MVAC p-p at pin 21 of J3 on Amplifier and Logic Assembly (Figure 5-6).
 - c. -15 VDC - Ripple - 80 MVAC p-p at pin 23 of J3 on Amplifier and Logic Assembly (Figure 5-6).
 - d. +220 VDC - Ripple - 5 VAC p-p at pin 41 on R/O and Counter Assembly (Figure 5-4).
 - e. -36 VDC - Ripple - 5 VAC p-p at pin 41 of J3 Amplifier and Logic Assembly (Figure 5-6).
 - f. If the above voltages are not within tolerance check the associated supply/s.
 - g. If the voltages are within tolerance, proceed to step 3.
3. Place function switch in MVDC position and range switch in H position. Short VDC input jack and measure zero volts at analog output connectors. Rotate DC and OHMS ZERO control from its extreme clockwise to counterwise positions; the analog output should vary approximately 12 millivolts. Apply plus one volt to VDC input, and measure plus three volts at the analog output connectors. Apply minus one volt to the VDC input and measure minus three volts at the analog output connectors.
 - a. If any of the above three measurements are not as specified, replace input amplifier A1 on Amplifier and Logic Assembly (Figure 5-6).
 - b. If the above measurements are as specified, proceed to step 4.
4. Apply minus one volt to VDC input with function switch in MVDC position and range switch in H position. Measure approximately minus 3.6 volts between TP8 (Figure 4-1) and ground.
 - a. If the above condition does not exist, replace A2 (Polarity Amplifier) on Amplifier and Logic Assembly (Figure 5-6).
 - b. If the above condition does exist, proceed to step 5.
5. Apply greater than two volts to VDC input with function switch in MVDC position and range switch in H position to cause the overload indicator ($\mathcal{Q}$) to illuminate. Connect the junction of R26 and R19 on R10 and Counter Assembly (Figure 5-4) to a plus five-volt source. The readout should extinguish. If it does not, check blanking circuit.
 - a. Set oscilloscope sensitivity controls

to 20 μ SEC/CM and 2 V/CM and connect leads to TP6 and ground. Clock pulses should appear as shown in Figure 4-7. If there are no clock pulses, check associated clock generators circuitry.

b. Change oscilloscope leads to TP5 and ground. Clock pulses should appear as shown in Figure 4-7. If they do not exist, check transistor Q8 on Amplifier and Logic Assembly (Figure 5-6) for operation. If Q8 is operating, replace comparator amplifier A3 on Amplifier and Logic Assembly (Figure 5-6).

c. If clock pulses appear as shown in Figure 4-7, proceed to step 6.

6. With the same conditions as set forth in step 5, connect leads of oscilloscope to TP10 and ground. Clock pulses

should appear as shown in Figure 4-7. If none exist, replace A4 on Amplifier and Logic Assembly (Figure 5-6).

a. If "up" clock pulses do exist, connect leads of oscilloscope to pin 14 of A4 on the R/O and Counter Assembly (Figure 5-4) and ground. If none exist, replace Q16 on the R/O and Counter Assembly.

b. If clock pulses, as shown in Figure 4-7, appear at pin 14 of A4, check for divide-by-ten clock pulses at pin 14 of A3 on R/O and Counter Assembly (Figure 5-4). If they do not exist, replace A4.

c. If divide-by-ten pulses exist at pin 14 of A3, check for divide-by-ten pulses at pin 14 of A2. If they do not exist, replace A3. Check for divide-by-ten pulses at pin 13 of A2, R/O and Counter Assembly. If they do not exist, replace A2.

d. If clock pulses exist in all of the above conditions, proceed to step 7.

7. Apply approximately one volt to VDC input with function switch in MVDC position and range switch in H position. If the readout displays an overload condition ($\overline{Q}$) and down pulses do not appear on oscilloscope with leads connected to TP7 (Figure 4-1) and ground, replace A5 on Amplifier and Logic Assembly (Figure 5-6).

8. Check to see if the weighted 1-2-4-8 bridge resistors are "falling in" correctly as each of the decade counters A2, A3 and A4 continuously count. Produce an overload condition and blank the readout as outlined in step 5.

a. With the sensitivity controls set to 100 μ SEC/CM and 0.5 V/CM connect the leads of oscilloscope to the junction of

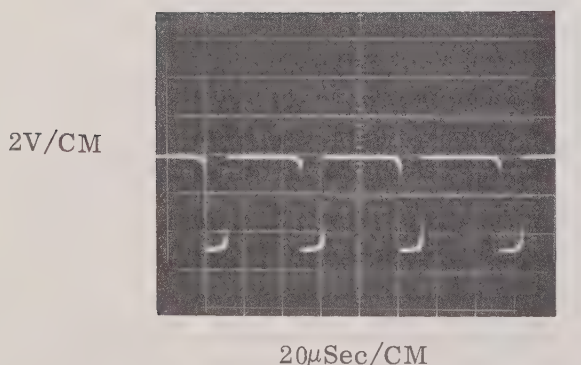


Figure 4-7. Clock Pulses

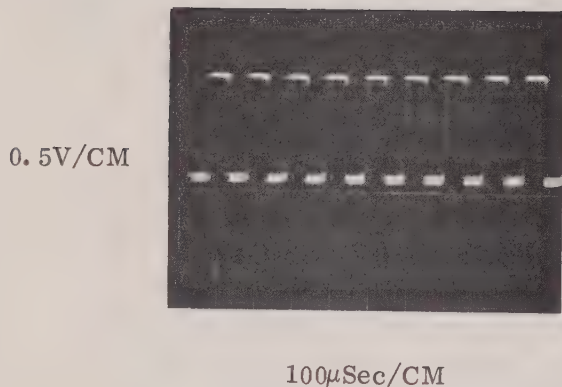


Figure 4-8. Decade "One Bit"

CR38 and R48 (Figure 5-7). The pattern displayed on oscilloscope should be as shown in Figure 4-8.

b. Change the oscilloscope leads to the junction of CR36 and R47 (Figure 5-7).

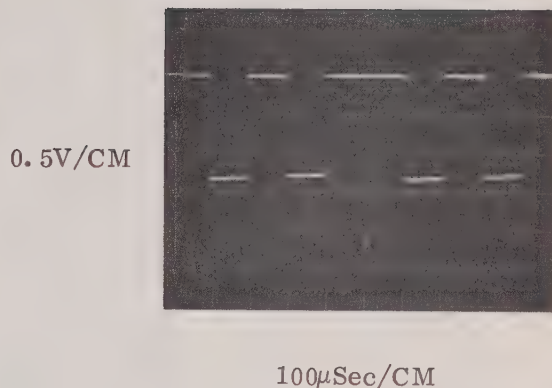


Figure 4-9. Decade "Two Bit"

The pattern displayed on oscilloscope should be as shown in Figure 4-9.

c. If the above conditions do not exist, check the associated bridge resistors and diodes.

CHAPTER V

PARTS LIST

This Chapter provides a list of electrical and electronic parts for the Series X-3 Digital Voltmeter. The parts are callout on photographs and are listed by circuit reference.

Manufacturers of all components called out in the parts lists are referred to by their Manufacturer's five-digit code number. Manufacturers and their codes are as follows:

Code	Manufacturer	Code	Manufacturer
00327	Welwyn International, Inc. Cleveland, Ohio	15605	Cutler-Hammer, Inc. Milwaukee, IL
01121	Allen Bradley Company 1201 South Second Street Milwaukee, WI	71590	Centralab Division of Globe- Union, Inc. 932 East Keife Avenue Milwaukee, WI
01295	Texas Instruments, Inc. Transistor Products Division Dallas, TX	73138	Helipot Division of Beckman Instruments, Inc. 2500 Harbor Boulevard Fullerton, CA
03607	Radio Corp. of America Commercial Electronic Products Division Los Angeles, CA	73445	Amperex Electronics Co. Division of North American Philips Co., Inc.
03626	Non-Linear Systems, Inc. P. O. Box N Del Mar, CA	75915	Littlefuse, Inc. 800 East Northwest Highway Des Plaines, IL
04713	Motorola, Inc. Semiconductor Products Division 5005 East McDowell Road Phoenix, AZ	77764	Resistance Products Co. 914 South 13th St. Harrisburg, PA
07263	Fairchild Camera & Instrument Corp. Semiconductor Division 313 Bayshore Frontage Road Mountain View, CA	80183	Sprague Products North Adams, MA
07436	Components, Inc. Van Nuys, CA	81483	International Rectifier Corp. 1523 East Grand Ave. El Segundo, CA
07793	Cornell-Dubilier Electronics Division Federal Pacific Electric Corp. 4144 Glencoe Avenue Venice, CA	83330	Smith Herman H., Inc. 2334 Nostrand Avenue Brooklyn, NY
14752	Electro Cube, Inc. 805 Fairway South Pasadena, CA	91418	Radio Materials Co. 2442 West Bryon Mawr. Chicago, IL
		91662	Elco Corp. Philadelphia, PA
99142	General Electric Co. Industrial Electronics Division of Electronic Atomic and Defense Systems Group Utica, NY		

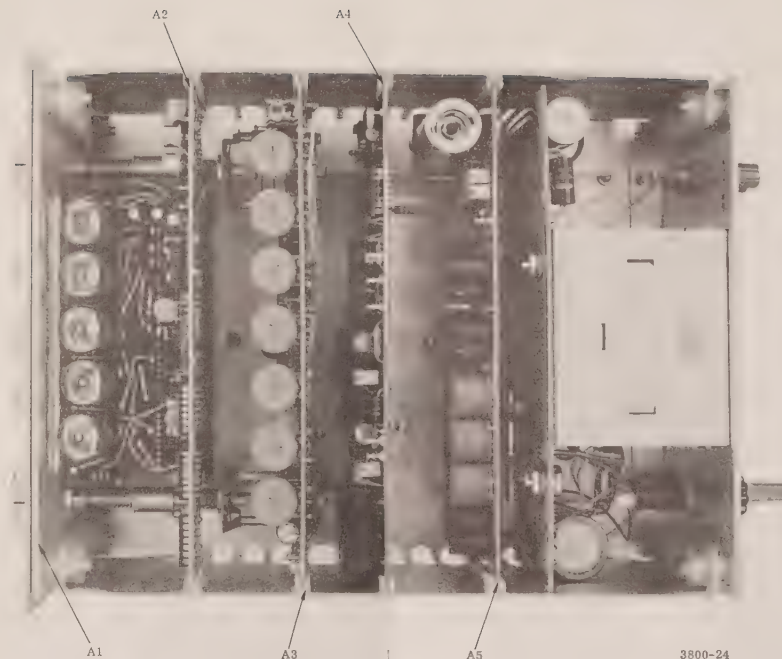


Figure 5-1. DVM Final Assembly

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY PER ASSY.	MANUFACTURER'S CODE
A1	38-128	DVM ASSEMBLY	1	03626
A2	38-115	R/O & COUNTER ASSEMBLY	1	03626
A3	38-98	ATTENUATOR ASSEMBLY	1	03626
A4	38-113	AMPLIFIER & LOGIC ASSEMBLY	1	03626
A5	38-107	D/A CONVERTER & REFERENCE ASSEMBLY	1	03626



Figure 5-2. DVM Assembly. Main Board and Power Supply

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY PER ASSY.	MANUFACTURER'S CODE
1	38-135	POWER SUPPLY BOARD ASSEMBLY	1	03626
F1	313.375	FUSE, 3AG 3/8A, SLO-BLO	1	75914
J5	277	PHONE JACK	1	83330
R1/S2	38-136	POTENTIOMETER/SWITCH, 350K	1	03626
R2	38-137	POTENTIOMETER, 350K, $\pm 20\%$	1	03626
R3	38-138	POTENTIOMETER, 350K, $\pm 20\%$	1	03626
R4	RC07GF754J	RESISTOR, 750K, 1/4W, 5%	1	01121
R5	RC20GF364J	RESISTOR, 360K, 1/2W, 5%	1	01121
S1	8280K21F	SWITCH, TOGGLE	1	15605
T1	D-261	TRANSFORMER	1	03626

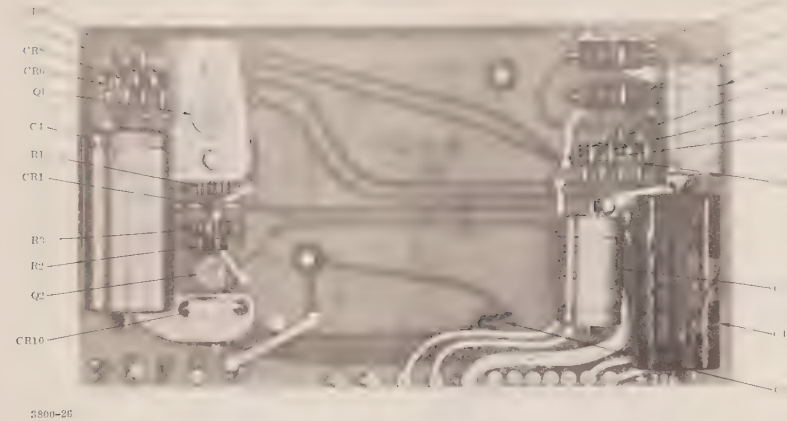
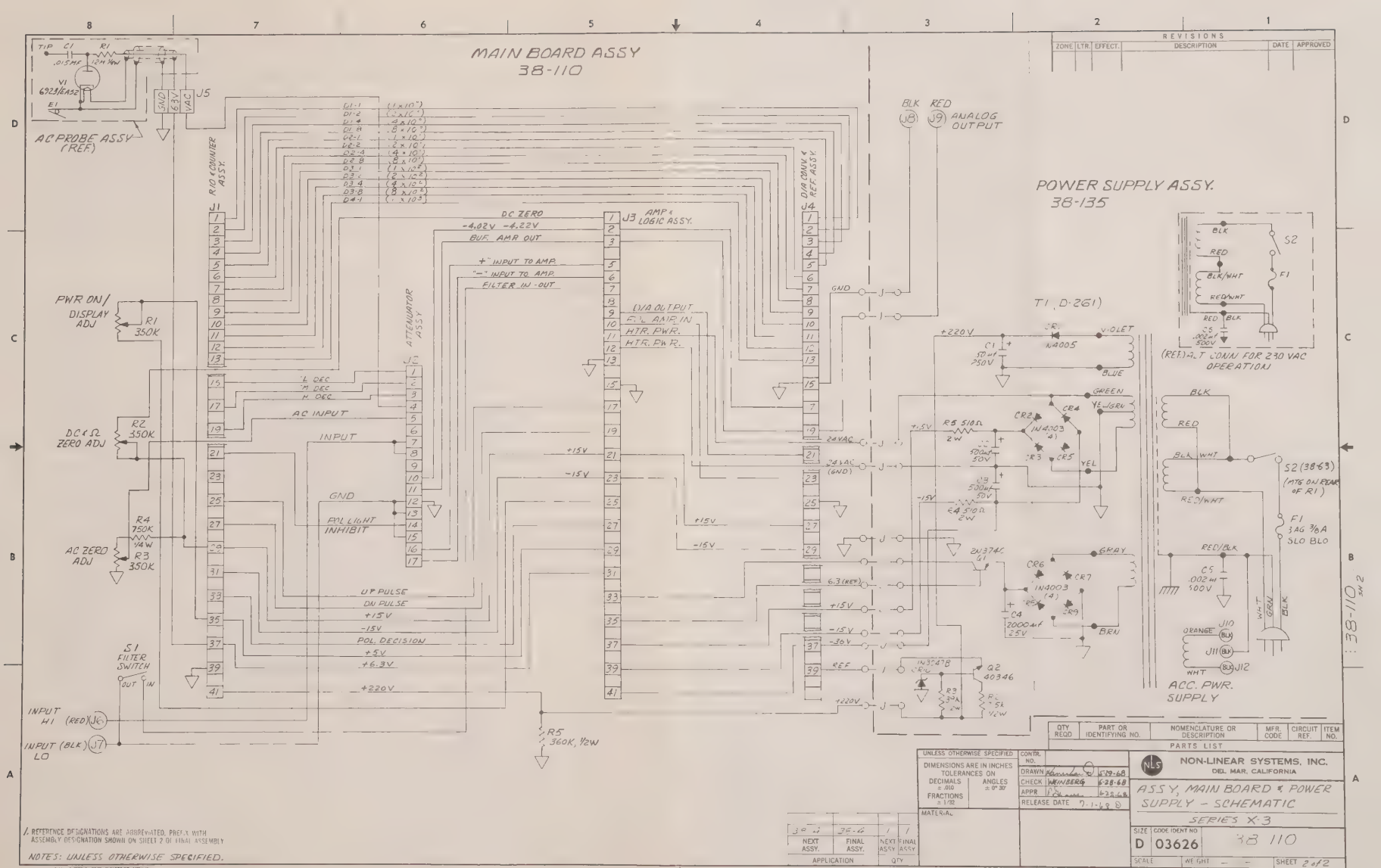
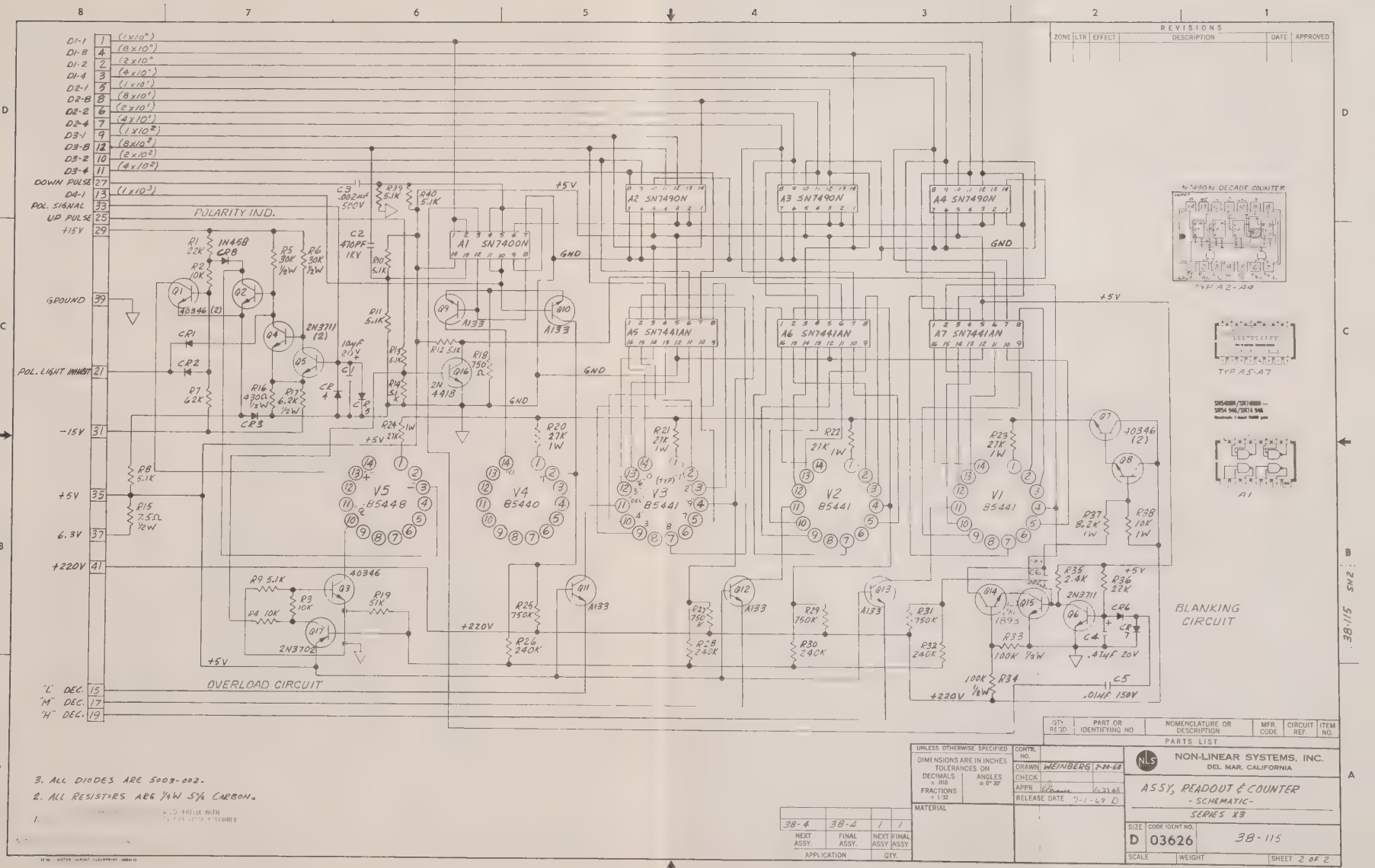


Figure 5-3. Power Supply Board Assembly

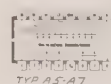
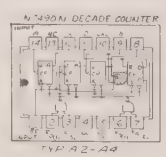
CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY PER ASSY.	MANUFACTURER'S CODE
C1	BR50-250	CAPACITOR, 50 μ F, 250V	1	07793
C2 & C3	2222-023-90011	CAPACITOR, 50 μ F, 50V	2	73445
C4	2222-063-90042	CAPACITOR, 200 μ F, 25V	1	73445
C5	5002-010	CAPACITOR, 0.002 μ F, 500V	1	03626
CR1	1N4005	DIODE	1	04713
CR2 thru CR9	1N4003	DIODE	8	04713
CR10	1N3047B	DIODE	1	02195
Q1	2N3740/2N3741*	TRANSISTOR	1	01295
Q2	40346	TRANSISTOR	1	03607
R1	RC20GF431J	RESISTOR, 430 Ω , 1/2W, 5%	1	01121
R2	RC20GF752J	RESISTOR, 7.5K, 1/2W, 5%	1	01121
R3	RC20GF393J	RESISTOR, 39K, 1/2W, 5%	1	01121
R4 & R5	RC20GF511J	RESISTOR, 510 Ω , 2W, 5%	2	01121

* Alternate





REVISIONS		DESCRIPTION	DATE	APPROVED
ZONE	LT/R			



QTY REQD	PART IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MFR CODE	CIRCUIT REF.	ITEM NO.
PARTS LIST					
NL5		NON-LINEAR SYSTEMS, INC. DEL MAR, CALIFORNIA			
ASSY, READOUT & COUNTER - SCHEMATIC - SERIES X3					
SIZE		CODE IDENT NO			
D		03626		38-115	
SCALE		WEIGHT		SHEET 2 OF 2	

UNLESS OTHERWISE SPECIFIED		CONTR. NO.
DIMENSIONS ARE IN INCHES		NO.
TOLERANCES ON		DRAWN
DECIMALS	ANGLES	CHECK
±.010	±.030	APPR
±.010	±.030	RELEASE DATE
MATERIAL		
38-4	38-4	1
NEXT ASSY.	FINAL ASSY.	NEXT FINAL ASSY.
APPLICATION		QTY.

3. ALL DIODES ARE 5008-002.
2. ALL RESISTORS ARE 1/4W 5% CARBON.
1.

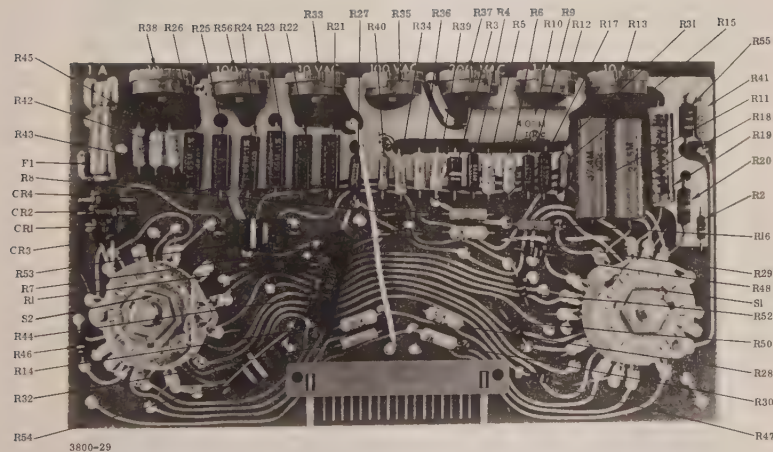
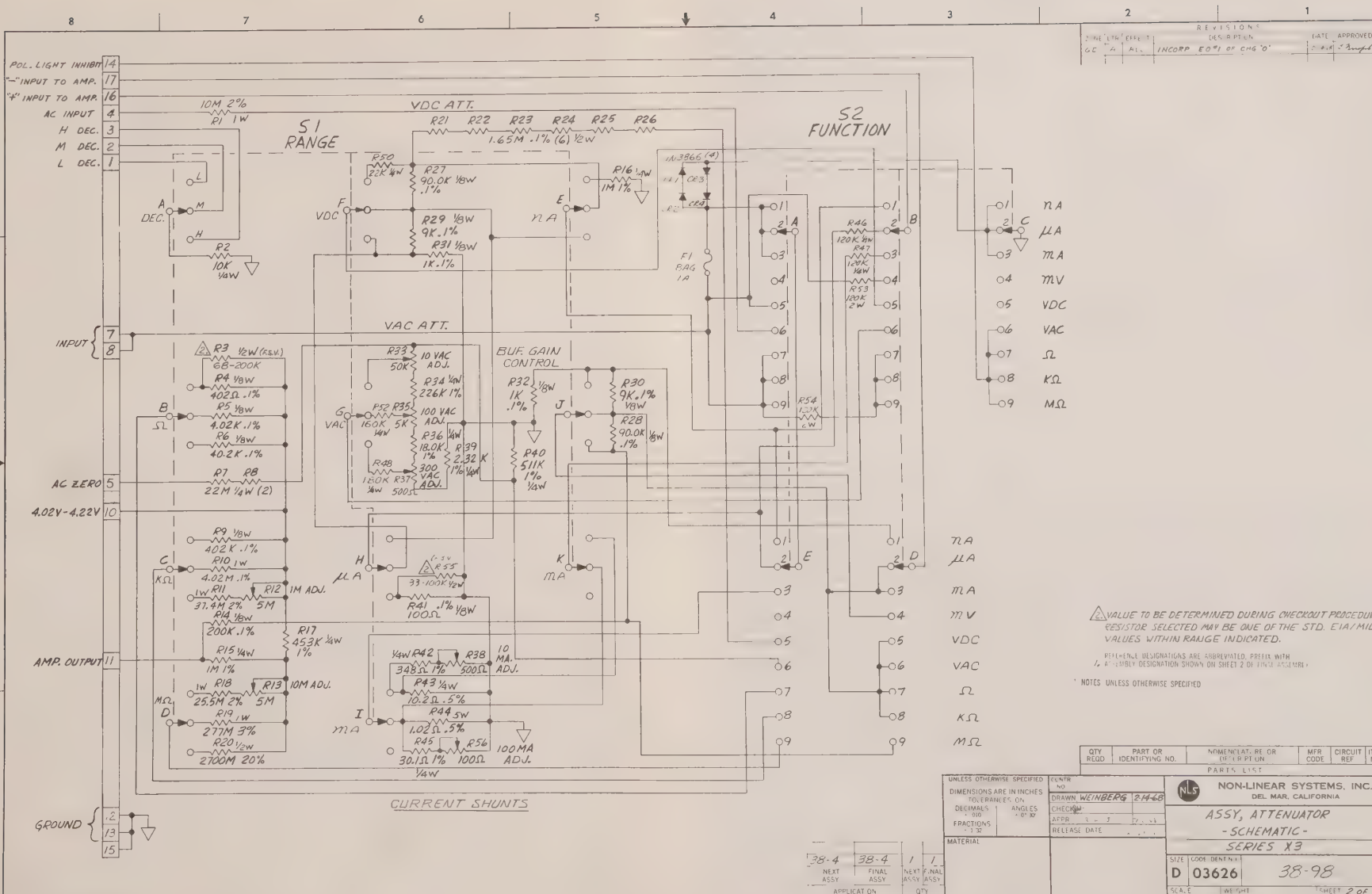


Figure 5-5. Attenuator Assembly

Attenuator Assembly, P/N 38-98				
CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY PER ASSY.	MANUFACTURER'S CODE
CR1 thru CR4	IN3866	DIODE	4	04713
F1	361001	FUSE 3AG 1A	1	75915
R1	RN75B1005G	RESISTOR, 10 Meg, 1W, 2%	1	01121
R2	RC07GF103J	RESISTOR, 10K, 1/4W, 5%	1	01121
R3	RC20GF	RESISTOR, 68K-200K, 1/2W, 5% (Factory Selected Value)	1	01121
R4	RN60C4020B	RESISTOR, 402K, 1/8W, 0.1%	1	01121
R5	RN60C4021B	RESISTOR, 4.02K, 1/8W, 0.1%	1	01121
R6	RN60C4022B	RESISTOR, 40.2K, 1/8W, 0.1%	1	01121
R7 & R8	RC07GF226J	RESISTOR, 22 Meg, 1/4W, 5%	2	01121
R9	RN60C4023B	RESISTOR, 402K, 1/8W, 0.1%	1	01121
R10	RN75C4024B	RESISTOR, 4.02 Meg, 1W, 0.1%	1	01121
R11	M13/RN75B3745G*	RESISTOR, 37.4 Meg, 1W, 2%	1	00327
R12 & R13	MOD. 9 - 5M	POTENTIOMETER, 5 Meg	2	71590
R14	RN60C2003B	RESISTOR, 200K, 1/4W, 0.1%	1	01121
R15 & R16	RN60D1004F	RESISTOR, 1 Meg, 1/4W, 0.1%	2	01121
R17	RN60D4533F	RESISTOR, 453K, 1/4W, 0.1%	2	01121
R18	RN75B2555G	RESISTOR, 25.5 Meg, 1W, 2%	1	01121
R19	BBFW277	RESISTOR, 277 Meg, 1W, 3%	1	77764
R20	RC20GF278M/ CBT 1/2*	RESISTOR, 2700 Meg, 1/2W, 20%	1	01121
R21 thru R26	RN70C1654B	RESISTOR, 1.65 Meg, 1/2W, 0.1%	6	01121
R27 & R28	RN60C9002B	RESISTOR, 90.0K, 1/8W, 0.1%	2	01121
R29 & R30	RN60C9001B	RESISTOR, 9K, 1/8W, 0.1%	2	01121
R31 & R32	RN60C1001B	RESISTOR, 1K, 1/8W, 0.1%	2	01121
R33	MOD. 9-50K	POTENTIOMETER, 50K	1	71590
R34	RN60D2263F	RESISTOR, 226K, 1/4W, 0.1%	1	01121
R35	MOD. 9-5K	POTENTIOMETER, 5K	1	71590
R36	RN60D1802F/ GP 1/2 *	RESISTOR, 18.0K, 1/4W, 0.1%	1	01121
R37 & R38	MOD. 9-500K	POTENTIOMETER, 500K	2	71590
R39	RN60D2321F	RESISTOR, 2.32K, 1/4W, 0.1%	1	01121
R40	RN60D5113F	RESISTOR, 511K, 1/4W, 0.1%	1	01121
R41	RN60C1000B	RESISTOR, 100K, 1/8W, 0.1%	1	01121
R42	RN60D3480F	RESISTOR, 348K, 1/4W, 0.1%	1	01121
R43	RN60D10R2D	RESISTOR, 10.2K, 1/4W, 0.5%	1	01121
R44	RW67VIR02D	RESISTOR, 1.02K, 5W, 0.5%	1	01121
R45	RN60D30R1F	RESISTOR, 30.1K, 1/4W, 0.1%	1	01121
R46 & R47	RC07GF124J	RESISTOR, 120K, 1/4W, 5%	2	01121
R48	RC07GF194J	RESISTOR, 180K, 1/4W, 5%	1	01121
R49	RC07GF223J	RESISTOR, 22K, 1/4W, 5%	1	01121
R50	RC07GF164J	RESISTOR, 160K, 1/4W, 5%	1	01121
R52	RC42GF124J	RESISTOR, 120K, 2W, 5%	2	01121
R53 & R54	RC20GF	RESISTOR, 33K, 100K, 1/2W, 5%	1	01121
R55	MOD. 9-100K	POTENTIOMETER, 100K	1	71590
R56	MOD. 9-100K	POTENTIOMETER, 100K	1	03626
S1	38-78	SWITCH, RANGE	1	03626
S2	38-79	SWITCH, FUNCTION	1	03626

* Alternate



REVISIONS		DATE	APPROVED
1	INCORP. E.O. 1 OF CHG. 01	2-14-68	J. H. J.

QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR CODE	CIRCUIT REF	ITEM NO.
-----	-------------------------	-----------------------------	----------	-------------	----------

UNLESS OTHERWISE SPECIFIED		DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS .005 FRACTIONS 1/32		PLANT NO. DRAWN WEINBERG 2448 CHECKED 2FPPB 1-3 27-33 RELEASE DATE	
MATERIAL		38-4 38-4 1 1 NEXT ASSY FINAL ASSY APPLICATION ON QTY		NON-LINEAR SYSTEMS, INC. DEL MAR, CALIFORNIA ASSY, ATTENUATOR -SCHEMATIC- SERIES X3	
SIZE CODE IDENT NO.		D 03626		38-98	
SCALE		WEIGHT		SHEET 2 OF 2	

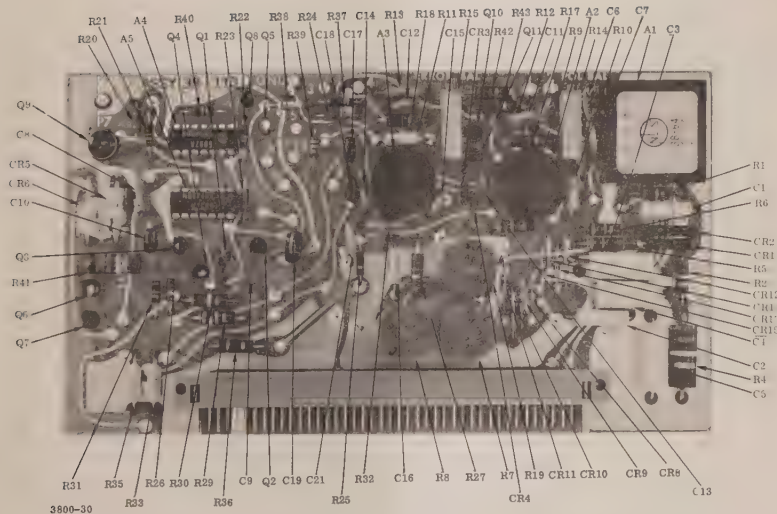
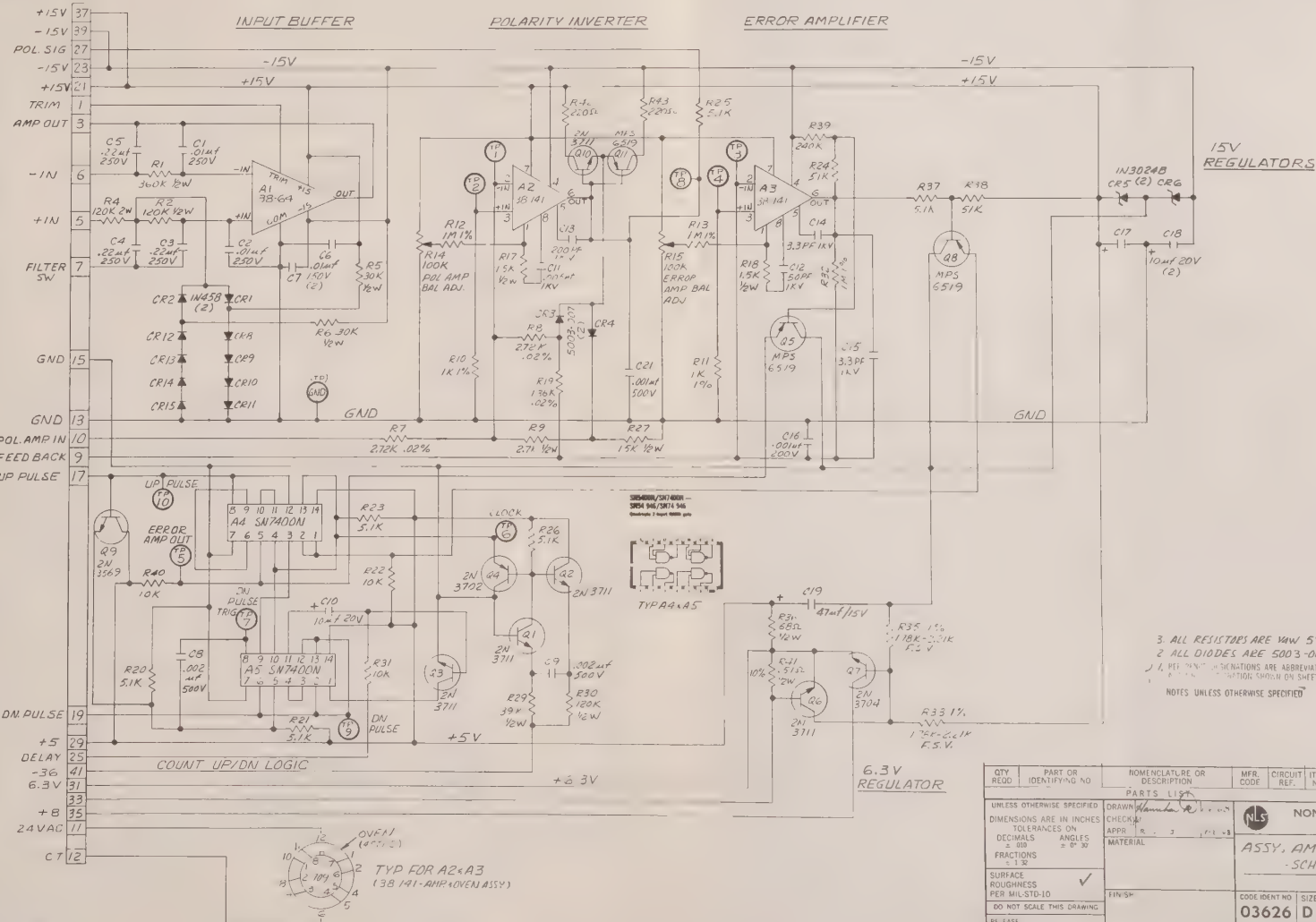


Figure 5-6. Amplifier and Logic Assembly

Amplifier and Logic Assembly, P/N 38-113				
CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY PER ASSY.	MANUFACTURER'S CODE
A1	38-64	AMPLIFIER	1	03626
A2 & A3	38-141	AMPLIFIER & OVEN ASSEMBLY	2	03626
A4 & A5	SN7400N	DIP, Quad 2 Input Gate	2	01295
C1 & C2	C281AB/A10K	CAPACITOR, 0.01 μ F, 250V	2	73445
C3, C4 & C5	C281AB/A220K	CAPACITOR, 0.22 μ F, 250V	3	73445
C6 & C7	DDM103	CAPACITOR, 0.01 μ F, 150V	2	71590
C8 & C9	5002-010	CAPACITOR, 0.002 μ F, 500V	2	03626
C10, C17 & C18	TS22-20-106	CAPACITOR, 10 μ F, 20V	3	07436
C11	BT005	CAPACITOR, 0.005 μ F, 100V	1	91418
C12	DD500	CAPACITOR, 50PF, 1KV	1	71590
C13	DD201	CAPACITOR, 200PF, 1KV	1	71590
C14 & C15	DD3R3	CAPACITOR, 3.3PF, 1KV	2	71590
C16	210B1C102	CAPACITOR, 0.001 μ F, 200V	1	14752
C19	TS24-15-476	CAPACITOR, 47 μ F, 15V	1	07436
C21	5002-011	CAPACITOR, 0.001 μ F, 500V	1	03626
CR1 & CR2	1N458	DIODE	2	04713
CR3 & CR4	5003-007/5325*	DIODE	2	03626
CR5 & CR6	1N3024B	DIODE, ZENER	2	01295
CR8 thru CR15	5003-002	DIODE	8	03626
Q1 thru Q3, Q6 & Q10	2N3711	TRANSISTOR	5	02195
Q4	2N3702	TRANSISTOR	1	2N3702
Q5, Q8 & Q11	MPS6519	TRANSISTOR	3	04713
Q7	2N3704	TRANSISTOR	1	02195
Q9	2N3638/2N3642*	TRANSISTOR	1	07263
R1	RC20GF64J	RESISTOR, 360K, 1/2W, 5%	1	01121
R2 & R30	RC20GF124J	RESISTOR, 120K, 1/2W, 5%	2	01121
R4	RC42GF124J	RESISTOR, 120K, 2W, 5%	1	01121
R5 & R6	RC20GF303J	RESISTOR, 30K, 1/2W, 5%	2	01121
R7 & R8	PW2016C-27200H	RESISTOR, 2.72K, 0.02%	2	03626
R9	RC20GF272J	RESISTOR, 2.7K, 1/2W, 5%	1	01121
R10 & R11	RN60D1001F	RESISTOR, 1K, 1/4W, 0.1%	2	01121
R12, R13 & R32	RN60D1004F	RESISTOR, 1 Meg, 1/4W, 0.1%	2	01121
R14 & R15	76P-R100K	POTENTIOMETER, 100K	2	73138
R17, R18 & R27	RC20GF152J	RESISTOR, 1.5K, 1/2W, 5%	3	01121
R19	PW2016C-13600H	RESISTOR, 1.36K, 0.02%	1	03626
R20, R21, R23 thru R26 & R37	RC07GF512J	RESISTOR, 5.1K, 1/4W, 5%	7	01121
R22, R31 & R40	RC07GF103J	RESISTOR, 10K, 1/4W, 5%	3	01121
R29	RC20GF393J	RESISTOR, 39K, 1/2W, 5%	1	01121
R33 & R35	RN60D/GP1/2*	RESISTOR, 1.78K, 2K, 2.1K, 2.21K, 1/4W, 0.1% (Factory Selected Values)	2	01121
R36	RC20GF680J	RESISTOR, 680, 1/2W, 5%	1	01121
R38	RC07GF513J	RESISTOR, 51K, 1/4W, 5%	1	01121
R39	RC07GF244J	RESISTOR, 240K, 1/4W, 5%	1	01121
R41	BW20/BWH*	RESISTOR, 0.510, 1/2W, 10%	1	
R42 & R43	RC07GF221J	RESISTOR, 220 Ω , 1/4W, 5%	2	01121

* Alternate

REVISIONS		DATE	APPROVED
NO.	DESCRIPTION		
1	10	ALL INDCORP 6.3V 1W 5% 0.10W 1W 24V 11.3	2/2/68 Rm 7



38 113
H2

3. ALL RESISTORS ARE 1/4W 5% CARBON.
2. ALL DIODES ARE 5003-002.
1. ALL PARTS ARE DESIGNATED BY A PREFIX WITH A NUMBER ON SHEET 2 OF THIS SPECIFICATION.
NOTES: UNLESS OTHERWISE SPECIFIED

QTY	RECD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO	38 4	38 4	1	1
PARTS LIST							38 4			
UNLESS OTHERWISE SPECIFIED							38 4			
DIMENSIONS ARE IN INCHES							38 4			
TOLERANCES ON							38 4			
DECIMALS							38 4			
ANGLES							38 4			
FRACTIONS							38 4			
SURFACE ROUGHNESS PER MIL-STD-10							38 4			
DO NOT SCALE THIS DRAWING							38 4			
RELEASE DATE							38 4			
DRAWN BY							38 4			
CHECKED BY							38 4			
MATERIAL							38 4			
FINISH							38 4			
CODE IDENT NO							38 4			
SIZE							38 4			
03626 D							38 4			
ALL							38 4			
ALIGHT							38 4			
SHEET							38 4			

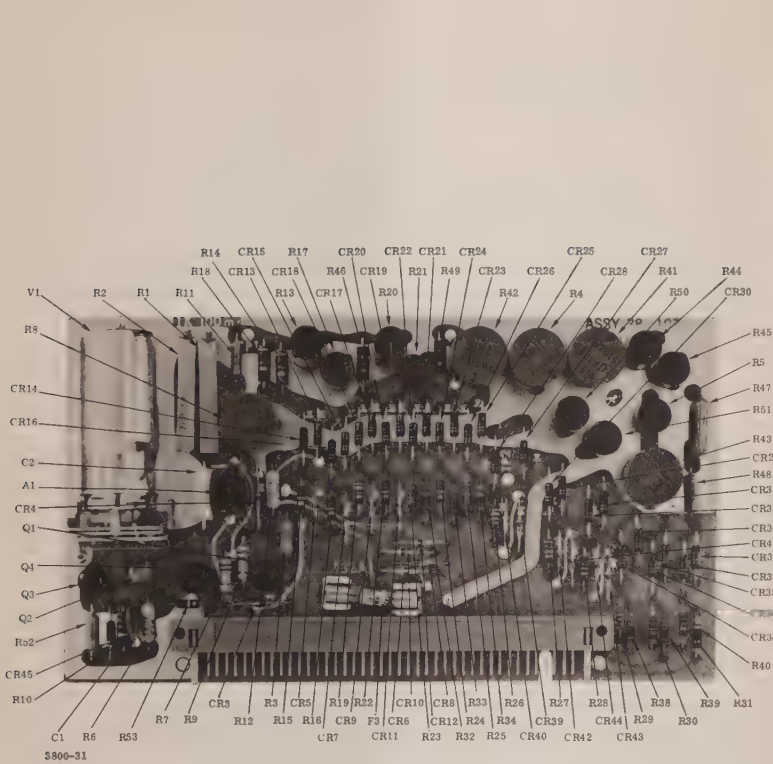


Figure 5-7. D/A Converter and Reference Assembly

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY PER ASSY.	MANUFACTURER'S CODE
A1	TD401	AMPLIFIER	1	80183
C1	5002-010	CAPACITOR, 0.002 μ F, 500V	1	03626
C2	C291AB/A10K	CAPACITOR, 0.01 μ F, 250V	1	73445
CR3 thru CR12 & CR39 thru CR44	5003-002	DIODE	16	03626
CR13 thru CR38	5003-007/S325*	DIODE	26	99142
CR45	1N751A	DIODE, ZENER	1	81483
F3	361.031	FUSE, 8AG, 1/32A	1	75915
Q1, Q3 & Q4	2N3645	TRANSISTOR	3	07263
Q2	A133/2N720A*/ 2N1893*	TRANSISTOR	1	
R1	78PR 200Q	POTENTIOMETER 200 Ω	1	71590
R2	78PR -5K	POTENTIOMETER, 5K	1	71590
R3	RN60D1004F	RESISTOR, 1M, 0.1%	1	01121
R4 & R43	PW2016C	RESISTOR, 1M, 0.05%	2	03626
R5	PW2016C	RESISTOR, 500K, 0.1%	1	03626
R6 & R12	RN60C3322F	RESISTOR, 33.2K, 0.1%	2	01121
R7	RN60D1103/GP42*	RESISTOR, 110K, 0.1%	1	01121
R8	PW2016C	RESISTOR, 0.02%	1	03626
R9	RN60D6812F/ GP42*	RESISTOR, 68.1K/68K*, 0.1%	1	01121
R10	RC20GF222J	RESISTOR, 2.2K, 1/2W, 5%	1	01121
R11	RN60CT873C	RESISTOR, 787K, 0.5%	1	01121
R13	PW2016CD	RESISTOR, DUAL 79.7K, 0.05%	1	03626
R17		99.7K, 0.05%		
R14 & R18	RC20GF	RESISTOR, 10-620 Ω , 1/2W (Factory Selected Value)	2	01121
R15 & R16	RC07GF223J	RESISTOR, 22K, 1/4W, 5%	2	01121
R19 & R26	RC07GF393J	RESISTOR, 39K, 1/4W, 5%	2	01121
R20	PW2016CD	RESISTOR, DUAL 199K, 0.05%	1	03626
R21		399K, 0.05%		
R22 thru R26 & R27 thru R31	RC07GF623J	RESISTOR, 62K, 1/4W, 5%	9	01121
R32 thru R34 & R38 thru R40	RC07GF302J	RESISTOR, 3K, 1/4W, 5%	6	01121
R41	PW2016C	RESISTOR, 800K, 0.05%	1	03626
R42	PW2016C	RESISTOR, 2 Meg, 0.1%	1	03626
R44	PW2016CD	RESISTOR, DUAL 200K, 0.1%	1	03626
R45		400K, 0.1%		
R46 & R49	RC20GF	RESISTOR, 10 Ω -2K, 1/2W (Factory Selected Value)	2	01121
R50	PW1224C	RESISTOR, 9K, 0.1%	1	03626
R51	PW1224C	RESISTOR, 473.7 Ω , 0.1%	1	03626
R52	RN60D1301F/ GP 1/2*	RESISTOR, 1.3K, 1%	1	01121
R53	RC07GF114J	RESISTOR, 110K, 1/4W, 5%	1	01121
V1	5651A	TUBE, REGULATOR	1	03607

* Alternate



CHAPTER VI

RECOMMENDED SPARE PARTS LIST

Part No.	Description	Qty
38-98	Attenuator Assembly	1
38-107	D/A Converter and Reference Assembly	1
38-113	Amplifier and Logic Assembly	1
38-115	R/O and Counter Assembly	1
38-64	Amplifier	1
38-141	Amplifier and Oven Assembly	1
IN3024B	Diode	1
IN3047B	Diode	1
IN3866	Diode	1
IN4003	Diode	1
IN4005	Diode	1
IN458	Diode	1
5003-002	Diode	5
5003-007	Diode	2
SN7400N	Dip, Quad Input Gate	1
SN7441AN	Dip, Decode Driver	1
SN7490N	Dip, Decade Counter	1
313.375	Fuse, 3A6, 3/8 A, Slo-Blo	6
3131001	Fuse, 3A6, 1A, Slo-Blo	6
361.031	Fuse, 8A6, 1/32 A, Slo-Blo	6
A133	Transistor	1
MPS6519	Transistor	1
2N1302	Transistor	1
2N3645	Transistor	1
2N3702	Transistor	1
2N3704	Transistor	1
2N3711	Transistor	3
2N3740	Transistor	1
2N4418	Transistor	1
40346	Transistor	1
B5440	Tube, Indicator (0 thru 9 & Decimal)	1
B5441	Tube, Indicator (0 and 1)	1
B5448	Tube, Indicator (Polarity & Φ)	1

APPENDIX

SHIPPING INSTRUCTIONS

Depending upon location, the choice of carrier will vary. Never ship an instrument to us without having received shipping instructions. If requested, an estimate of charges can be made before work begins.

Be certain to pack the instrument carefully; while an outer and inner box, separated by two or three inches of excelsior is desirable, the instrument can be placed into a single container provided it is so packed that it will not shift about. As with the double box method, use two or three inches of shock-absorbent packing materials. The instrument itself should be first wrapped in heavy

paper so as to keep excelsior or other particles from entering the instrument's louvers. If the original shipping container is in good condition, it may be used.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to Non-Linear Systems, Inc. After receiving such a report we will advise you of the disposition of the instrument and arrange for its repair or replacement. Be certain to include model and serial number when corresponding.

non linear
 systems, inc.
DEL MAR, CALIFORNIA

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